



# **Instantaneous Identification of Forged Valuable Documents Using an Advanced Spectroscopy Technique: Application to Banknotes**

**By Dr. Antoine GHAUCH**

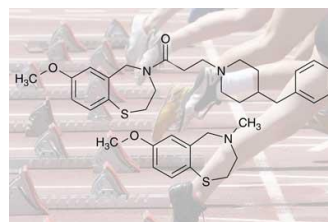
American University of Beirut

Chemistry Department

**GCC Forensics Exhibition, 2018  
October 31, 2.00-3.00 PM  
Abu Dhabi, UAE**



# SACOS: Smart Anti-Counterfeiting Optical System





**PATENT FILED in the US through the  
OGC at AUB on November 3, 2014**



**USAID**  
FROM THE AMERICAN PEOPLE

## The Technology Transfer Unit

**Provisional Patent filed on November 3, 2014.**



### UNITED STATES PATENT AND TRADEMARK OFFICE

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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY. DOCKET NO	TOT CLAIMS	IND CLAIMS
62/074,396	11/03/2014		160	6161-012		

29335  
ROSENBAUM IP  
1480 TECHNY ROAD  
NORTHBROOK, IL 60062

**CONFIRMATION NO. 8648**

**UPDATED FILING RECEIPT**



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**Extend toward international Patent! Europe, Asia!**

Dr. Antoine Ghauch | AUB | GCC

# PATENT FILED at WIPO through the OGC at AUB on November 2, 2015



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## 1. (WO2016071771) SMART ANTI-COUNTERFEITING OPTICAL SYSTEM (SACOS) FOR THE DETECTION OF FRAUD USING ADVANCED SPECTROSCOPY-BASED TECHNIQUE

PCT Biblio. Data Description Claims National Phase Notices Drawings Documents

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Publication Date: 12.05.2016 International Filing Date: 02.11.2015  
IPC: G07D 7/12 (2016.01), G07D 7/20 (2016.01)

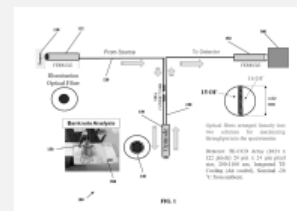
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GHAUCH, Antoine [FR/LB]; (LB)

Inventors: GHAUCH, Antoine; (LB).  
AMMOURI, Ali; (LB)

Priority Data: 62/074,396 03.11.2014 US

Title: (EN) SMART ANTI-COUNTERFEITING OPTICAL SYSTEM (SACOS) FOR THE DETECTION OF FRAUD USING ADVANCED SPECTROSCOPY-BASED TECHNIQUE  
(FR) SYSTÈME OPTIQUE ANTI-CONTREFAÇON INTELLIGENT (SACOS) POUR LA DÉTECTION DE LA FRAUDE À L'AIDE D'UNE TECHNIQUE AVANCÉE BASÉE SUR LA SPECTROSCOPIE

Abstract: (EN)The SACOS apparatus solves counterfeiting issues instantaneously and can help in developing new security features in order to help improving the role that international regulatory commissions, governments and central banks play to effectively fight counterfeiting.  
(FR)La présente invention concerne un appareil SACOS qui résout instantanément les problèmes de contrefaçon, et qui peut contribuer à la création de nouveaux éléments de sécurité afin d'aider à améliorer le rôle joué par les commissions réglementaires internationales, les gouvernements et les banques centrales dans la lutte efficace contre la contrefaçon.



Designated States: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.  
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European Patent Office (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR)  
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(54) SMART ANTI-COUNTERFEITING OPTICAL SYSTEM (SACOS) FOR THE DETECTION OF FRAUD USING ADVANCED SPECTROSCOPY-BASED TECHNIQUE

(71) Applicant: AMERICAN UNIVERSITY OF BEIRUT, Beirut (LB)

(72) Inventors: Antoine Ghauch, North-Chiyah (LB); Ali Ammouri, Ghobeiri (LB)

(21) Appl. No.: 15/582,295

(22) Filed: Apr. 28, 2017

## Related U.S. Application Data

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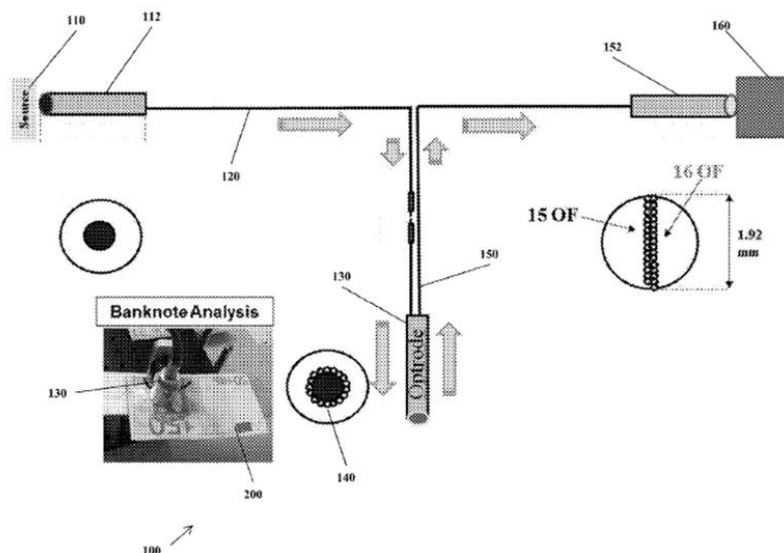
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CPC ..... G07D 7/1205 (2017.05); G01N 21/474 (2013.01); G01N 21/64 (2013.01); G07D 7/205 (2013.01); G01N 21/17 (2013.01); G01N 2021/5957 (2013.01); G01N 2021/6434 (2013.01); G01N 2021/3196 (2013.01)

## (57) ABSTRACT

The SACOS apparatus solves counterfeiting issues instantaneously and develops new security features in order to improve the role that international regulatory commissions, governments, and central banks play to effectively fight counterfeiting.



# OUTLINE

1. Rationale behind: Toxins Detection (Origin and Sources)
2. Major Water and Soil Pollutants (POISONS)!
3. Classical vs Advanced Analytical Techniques (Sensors)
4. Technical Aspects and Challenges
5. New Applications to Explore: Paper Mills, Central Banks, and Forensics...Home Land Security.
6. Research Impact and Societal Outcomes
7. Conclusion (Scenario)
8. QA





# Challenges

**How Technical Limitations Can be used as an Advantage for New Discoveries in Analytical Chemistry and Instrumentation?**

**From Classic Analytical Techniques**

**To Innovative Techniques**

**From Classic Applications**

**To Innovative Applications**

# 1. SACOS Principle and Counterfeiting Measurements

## Major Water and Soil Pollutants (Common and Emergent)

### • Organic Pollutants

- Pesticides (chlorinated, phosphorus, triazines, etc...)
- Polycyclic Aromatic Hydrocarbons (+ BTEX, etc...)
- Pharmaceutical compounds or Drugs (Emergent)
- **Explosives**



### • Inorganic Pollutants

- Nitrate
- Phosphate
- Chromium (VI) Carcinogen
- Arsenic
- Lead ( $Pb^{2+}$ )
- Cyanide...
- **Poisons**



**Intentional and/or  
Accidental Pollution**



# 1. SACOS Principle and Counterfeiting Measurements

## Classical vs Advanced Analytical Techniques

- ✓ Chromatography (Organic, Ions)
- ✓ Atomic Absorption (Furnace, Flame), Atomic Emission (Plasma)

1. **Advantages:** Very accurate, reproducible, automated, etc.

2. **Disadvantages:** Very expensive, continuous maintenance, heavy techniques, not transportable, impossible field application, high energy consumption, etc...

## Unusual Analytical Techniques (Miniaturized)

- Electrochemical Based-Sensors
- Spectroscopy-Based Chemical Sensors
- Bio Sensors

1. **Advantages:** Robust, in-situ application, Very sensitive, Rapid, Reproducible, Moderate cost, Less frequent maintenance, Transportable techniques, Easily adaptable for field application, Wireless connection for data collection and alert launch (sms, e-mail, etc...)

2. **Disadvantages:** Do not cover all chemicals, but can easily and successfully give a pollution indicator in case of accidental pollution for example.

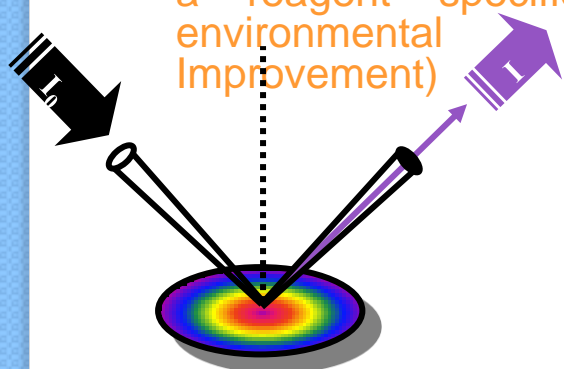
# 1. SACOS Principle and Counterfeiting Measurements

## Classical vs Advanced techniques

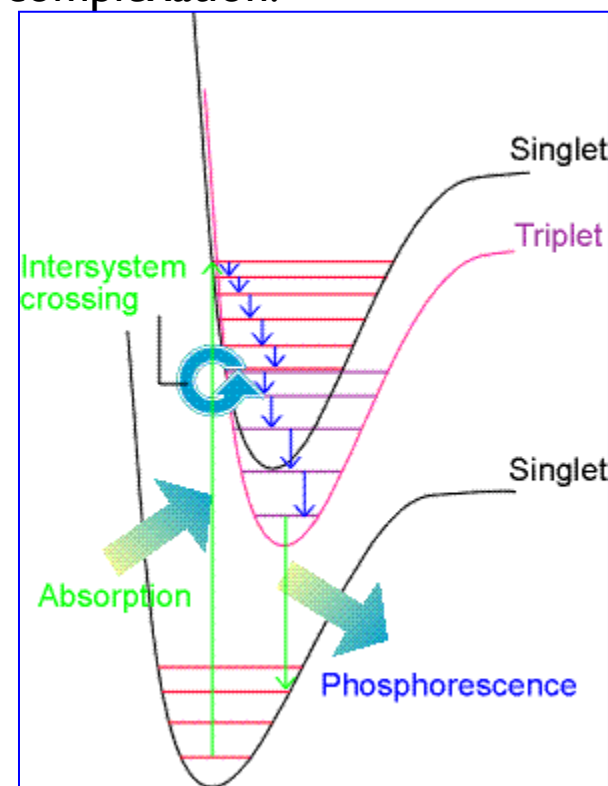
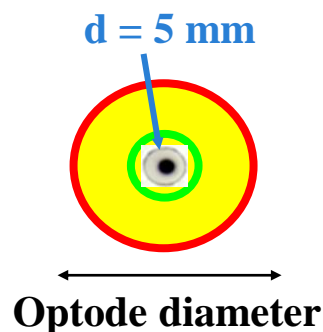
- **Optical Sensing Applications**
  - Diffuse Reflectance Spectroscopy (inorganic species by complexation (color development)).
  - Solid Matrix Room Temperature Phosphorescence (SM-RTP) for organic species as well as inorganic species after complexation.

- The SM can be a New Filter paper (cellulose based) or an engineered polymer to induce good analyte emissive properties.

- A manipulated Solid Surface impregnated with a reagent specific to some probes of environmental interest (Selectivity Improvement)



Colored Solid Matrix



Ghauch et al. (1999) *Talanta* **48**, 385-392.  
Ghauch et al. (2000) *Chemosphere* **40**, 1327-1333.  
Ghauch et al. (2000) *Anal. Lett.* **33**, 709-728.  
Ghauch et al. (2000) *Talanta* **51**, 807-816.  
Ghauch, A. (2000) *Fresen. J. Anal. Chem.* **367**, 545-550.



# SACOS Principle and Counterfeiting Measurements

## Technical Aspects / Challenges

Sensors,...Electrochemical,

1

Excite



2

Interact



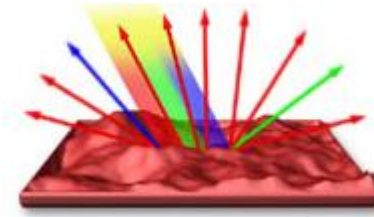
Combination of optical  
and electronic devices

Optical,

Biological...

3

Emit



4

Collect

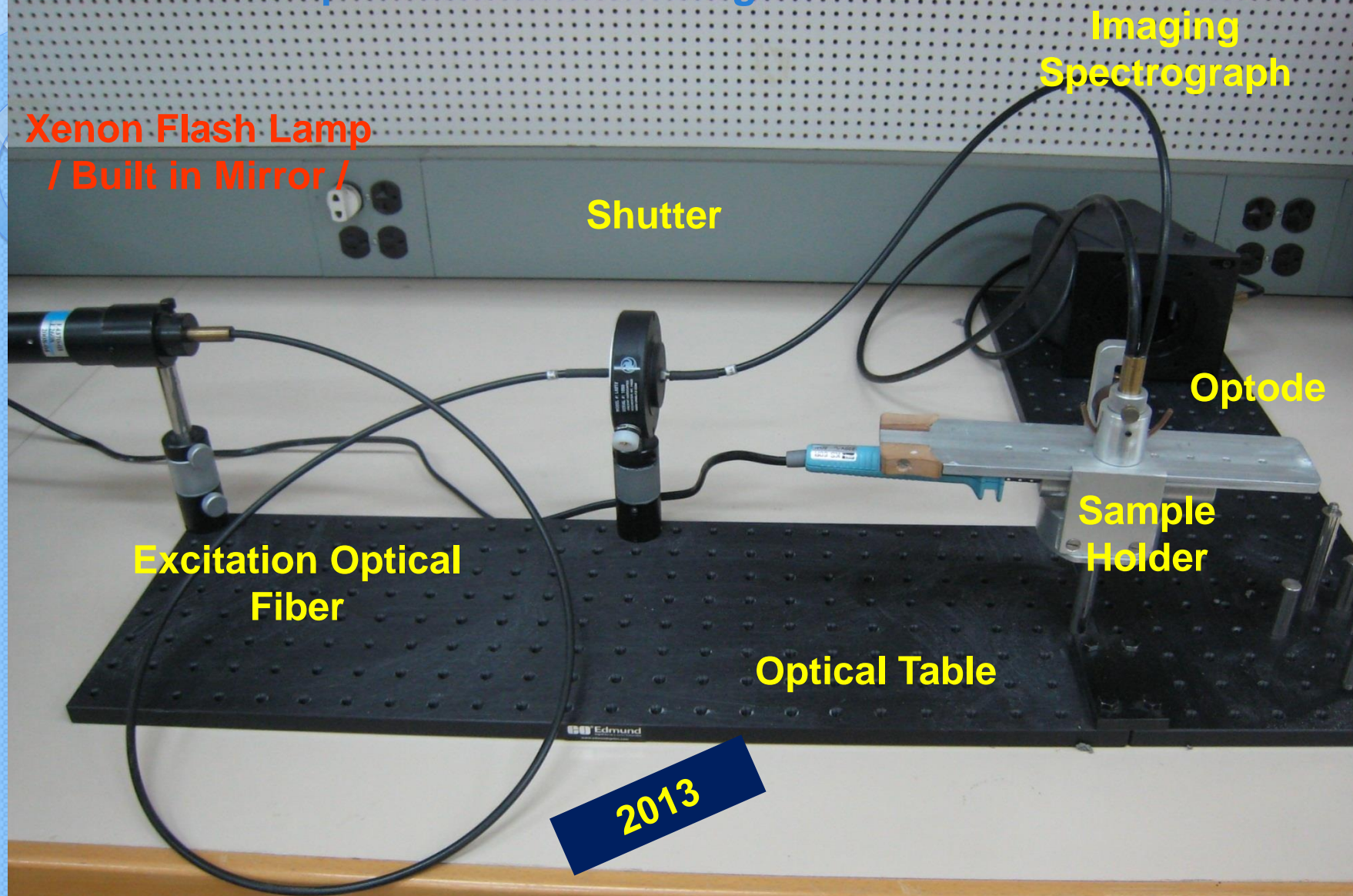
5

Treat

Yielding an Engineered System

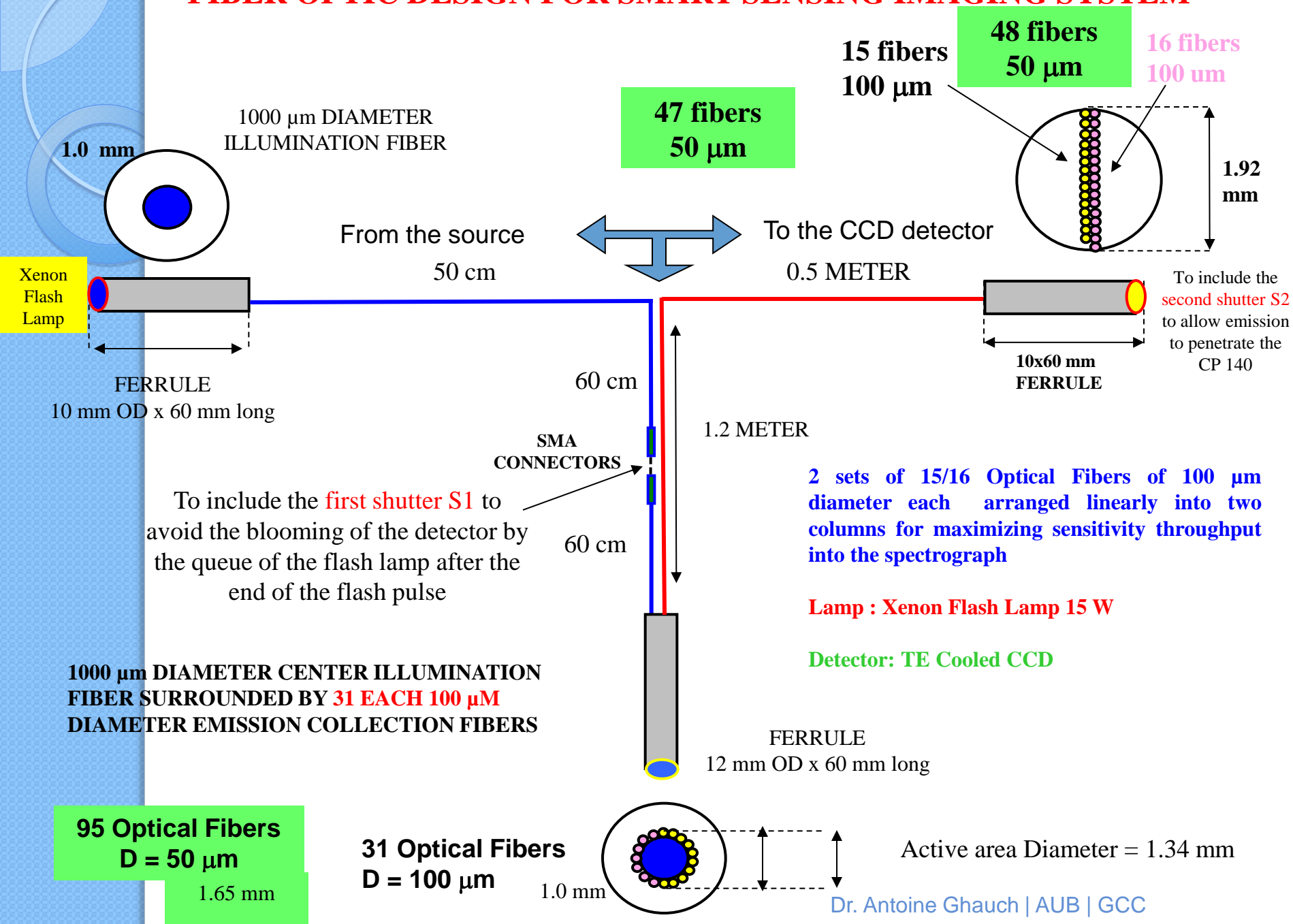
Toward ..... Patent, Commercialization

## SACOS Principle and Counterfeiting Measurements



Incomplete Set up of the smart sensing device to instantaneously measure traces of organic compounds in water

# FIBER OPTIC DESIGN FOR SMART SENSING IMAGING SYSTEM





# On-going Research SACOS connected: Forensic Application (4)

## New PEER GRANT (2017-2020)



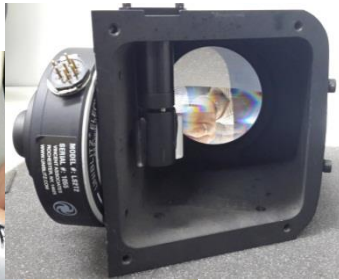
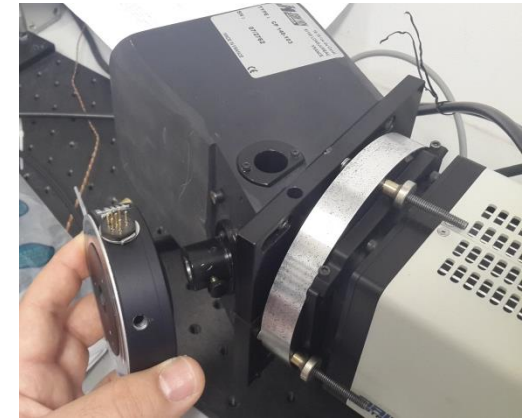


## 4. Technical Aspects / Challenges

### Challenges: Shutter installation / Detector Plate Adaptor



Detector Adaptor



Shutter  
Adaptation

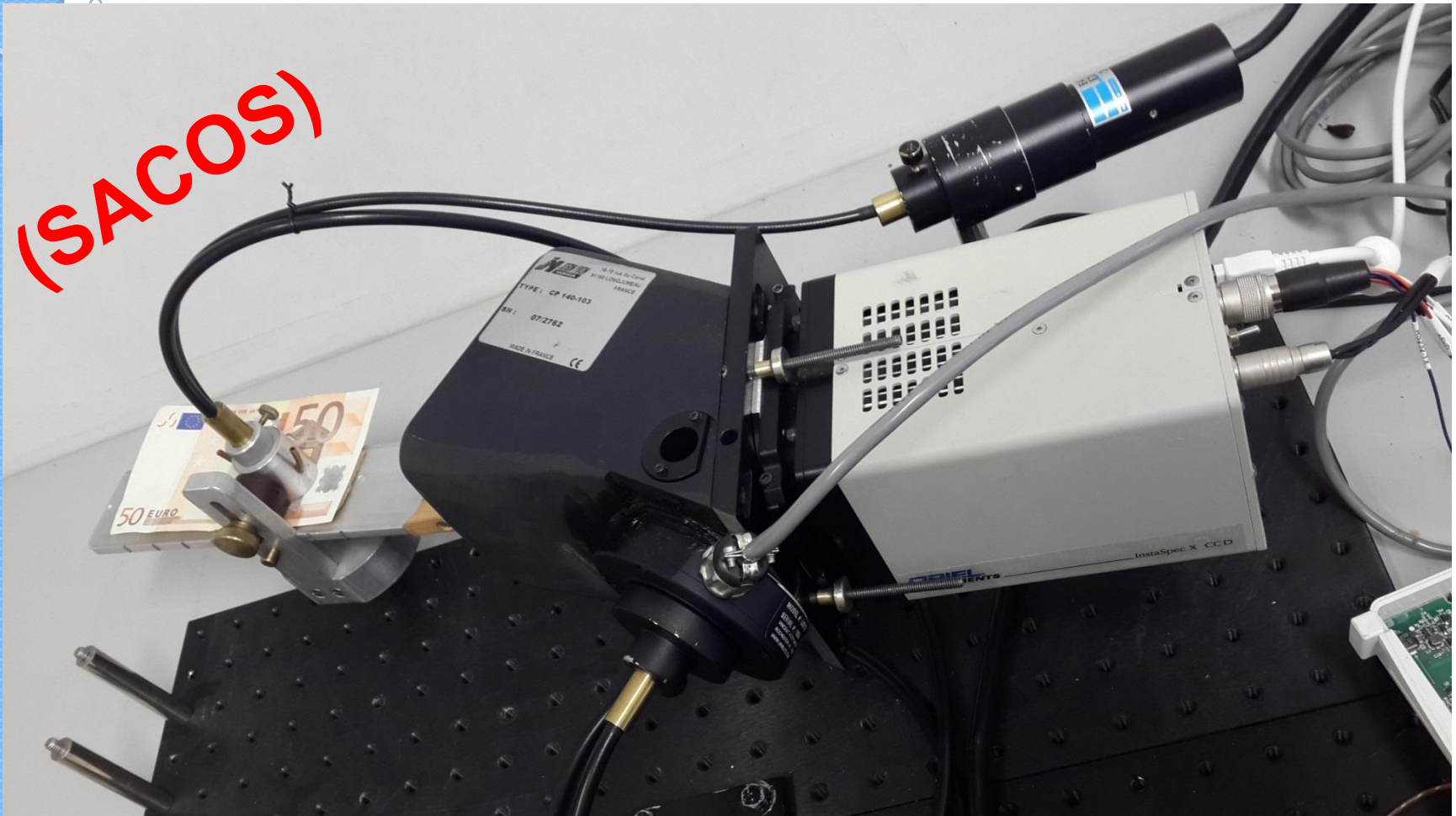


Shutter Fixation at the  
entrance of the  
Spectrograph



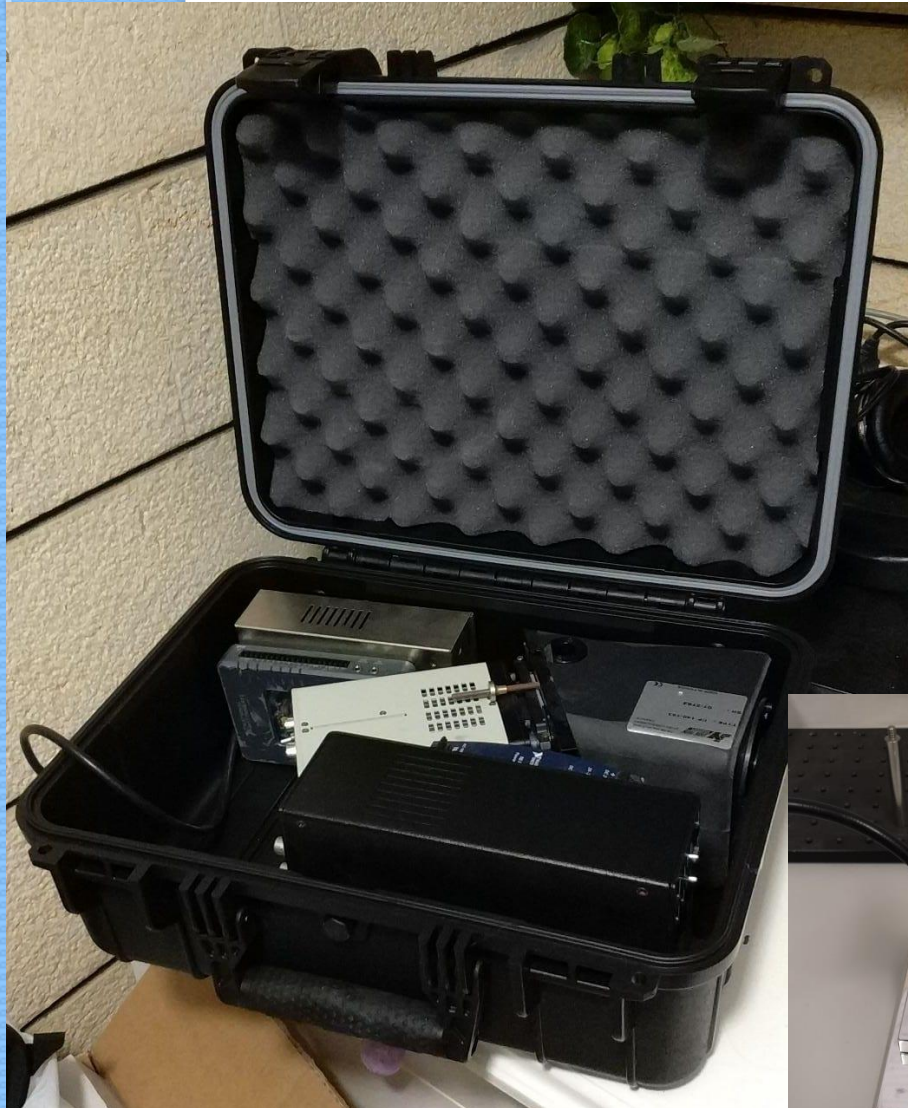
# SACOS Principle and Counterfeiting Measurements

## Smart Anti-Counterfeiting Optical Sensor



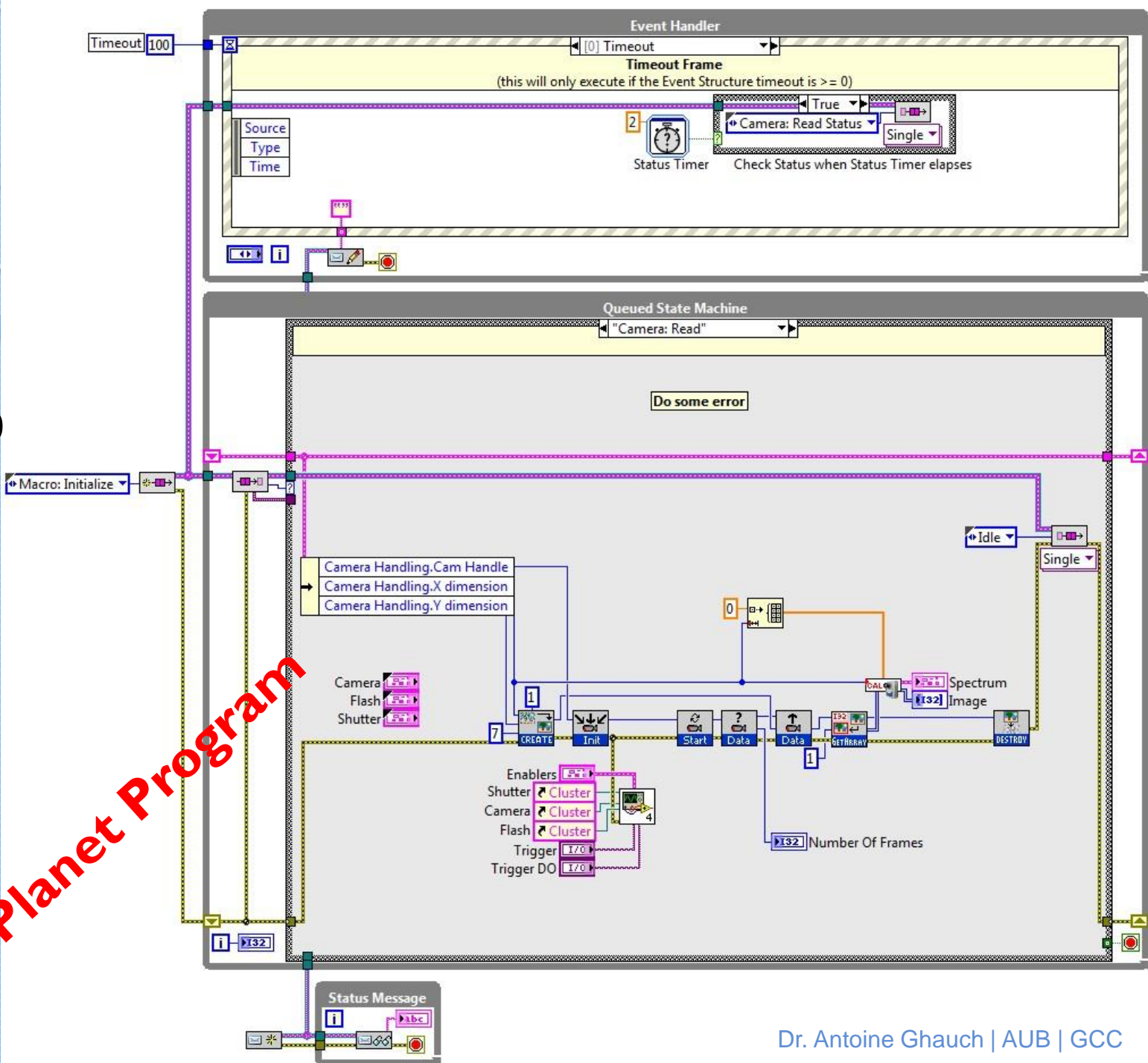


# PORTABLE VERSION



# Block Diagram

NI Planet Program

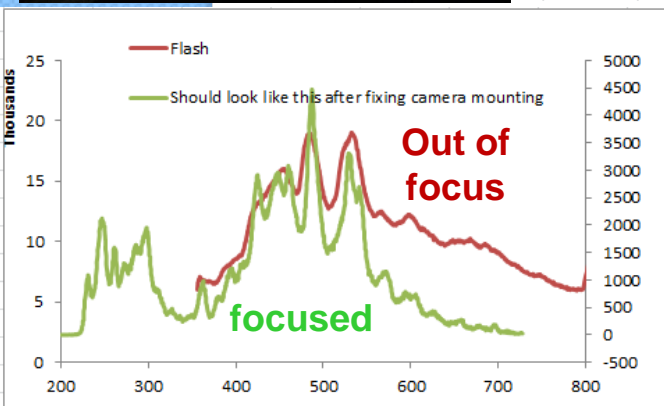
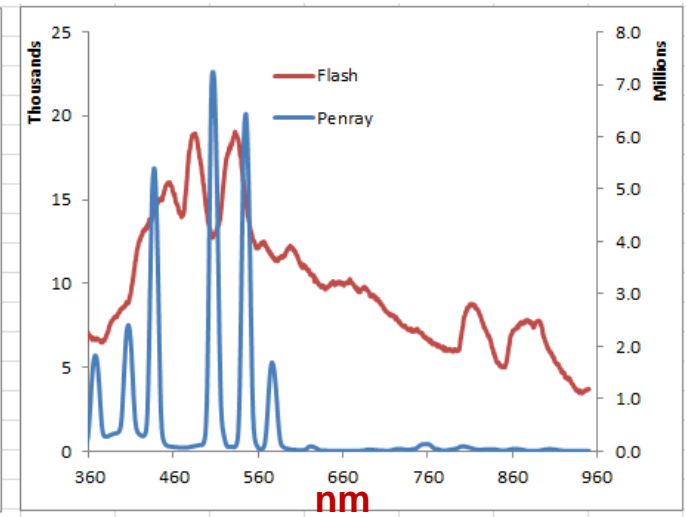
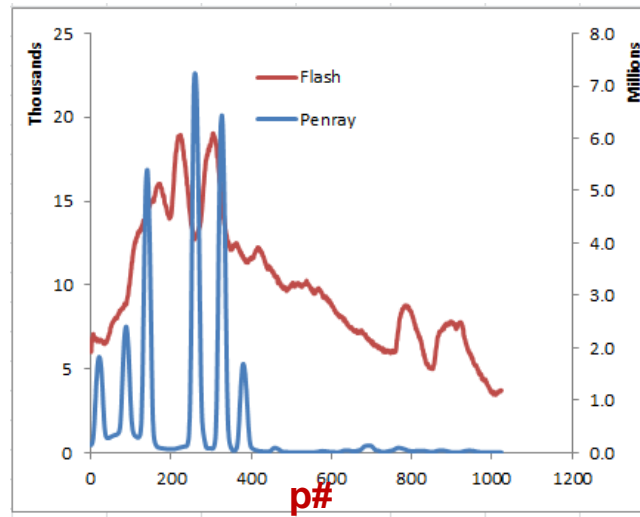


LabVIEW Code

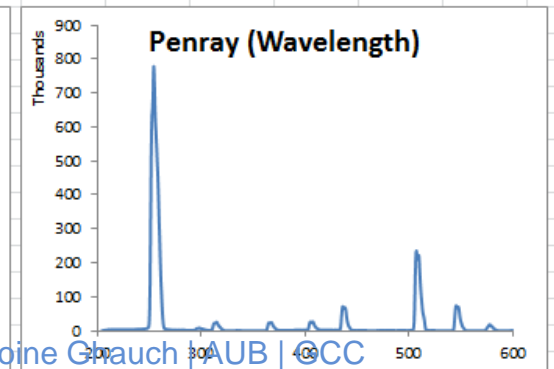
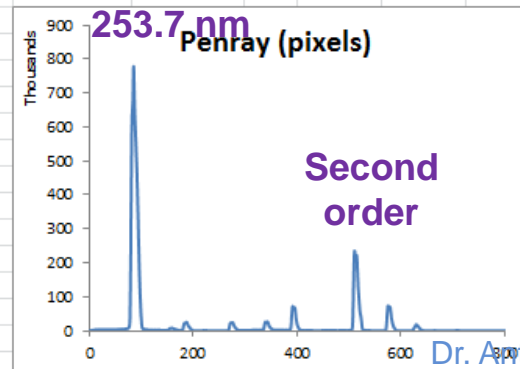
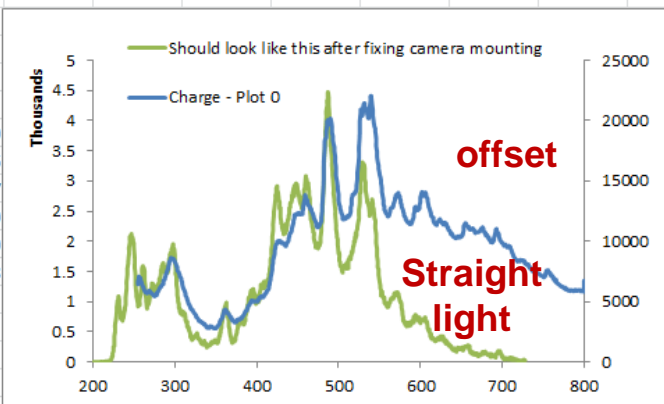
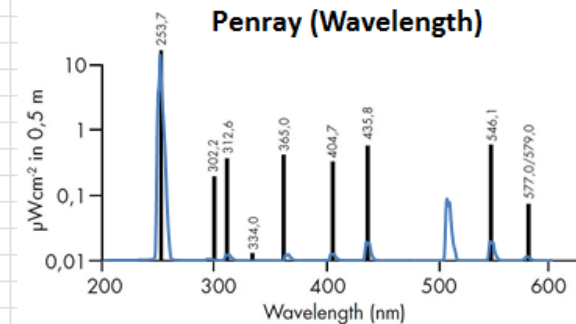


# Calibration Phase

Localization of the focal plane

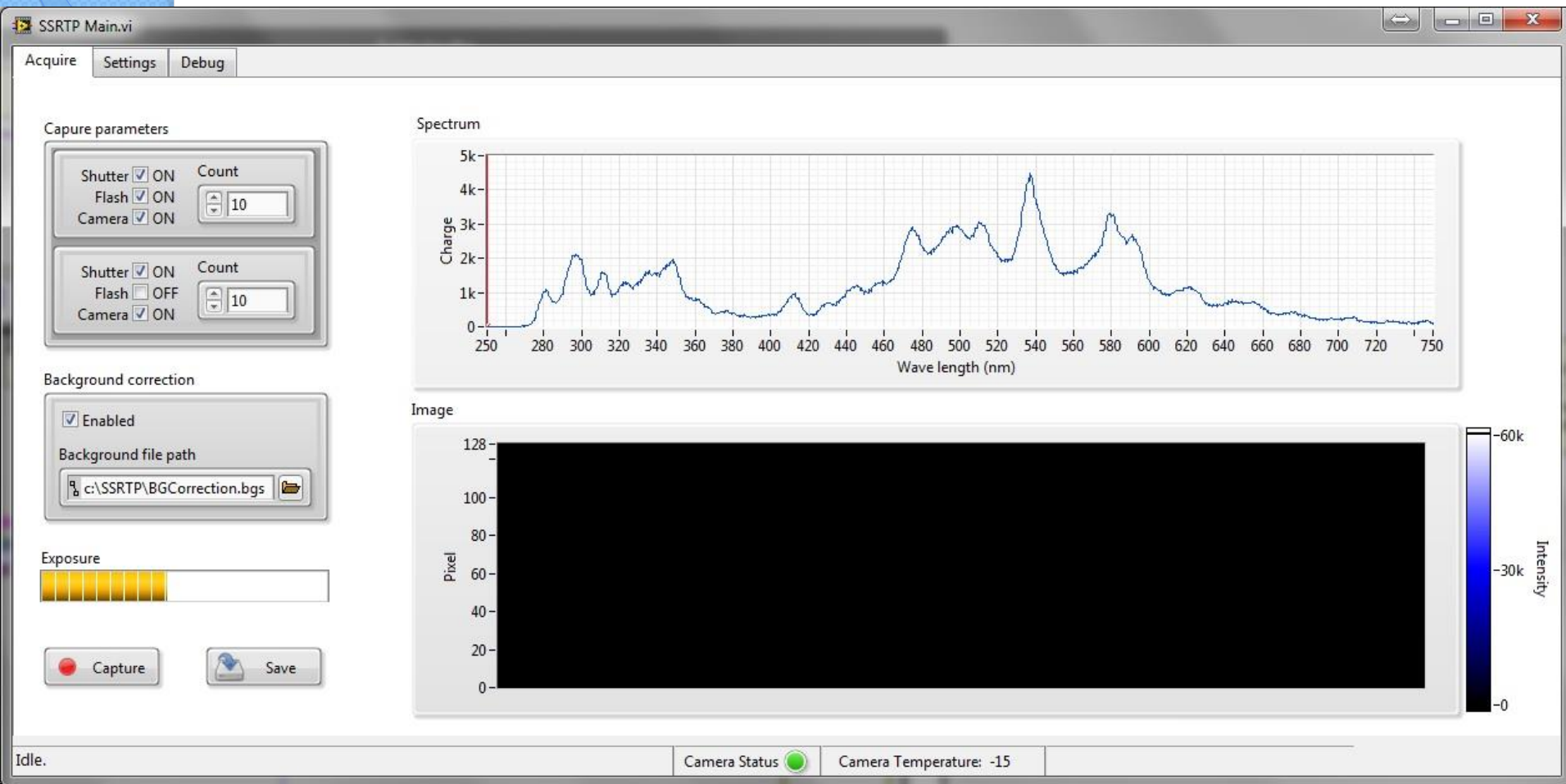


Calibration		
Pixel	Wavelength	Error
85	253.7	0.38
159	302.2	4.16
187	312.6	2.08
220	334	0.28
275	365	1.96
339	404.7	0.28
391	435.8	0.07
511	507.4	0.24
575	546.1	0.92
629	577	0.26
		10.62
slope	0.59	
intercept	203.58	



# SACOS Principle and Counterfeiting Measurements

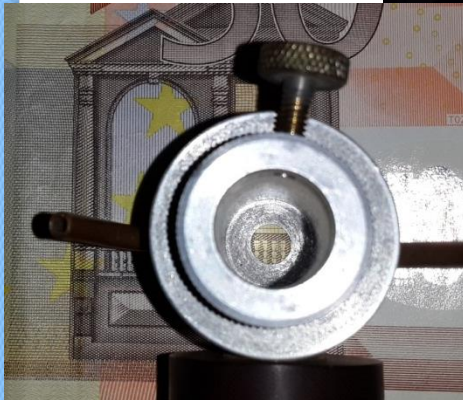
## Front Panel (User Interface)



# SACOS Principle and Counterfeiting Measurements

**New Applications to Explore: Home Land Security...Safety**

- Finance, Counterfeiting bands, etc...**

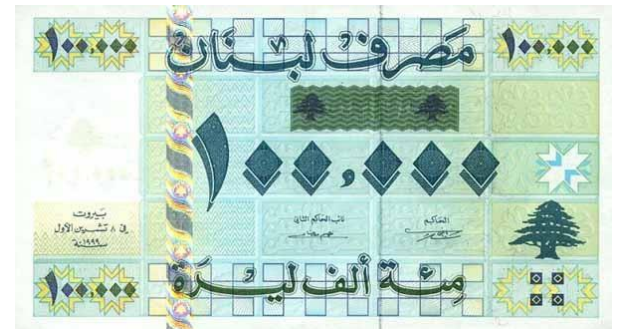
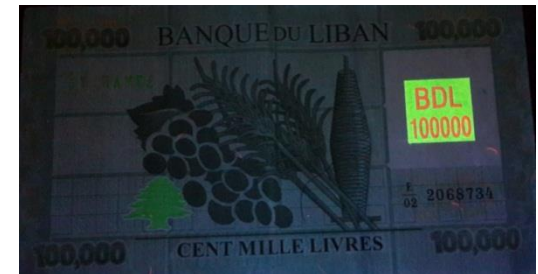
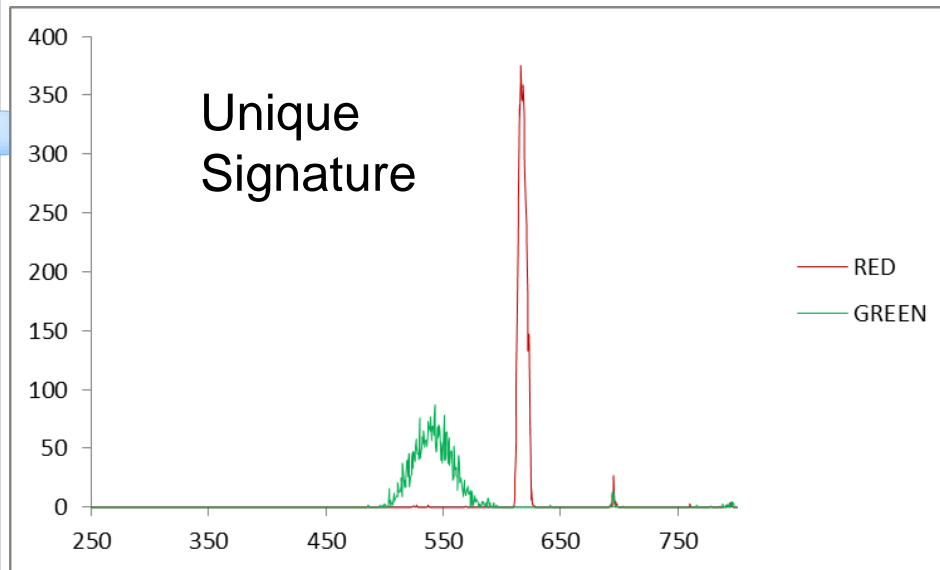


**Non  
destructive**

**Instantaneous**



# SACOS Principle and Counterfeiting Measurements

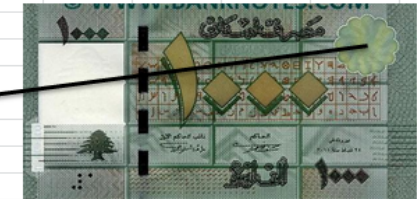
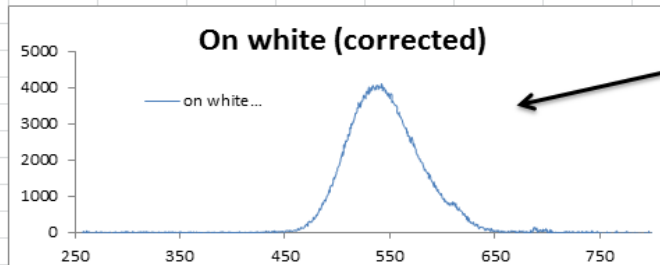
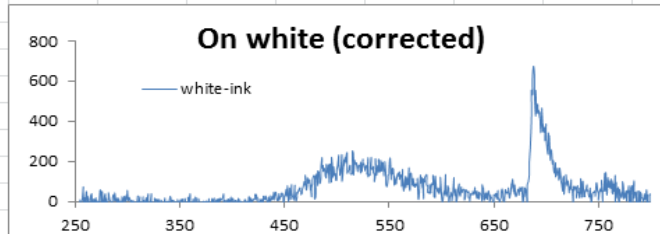
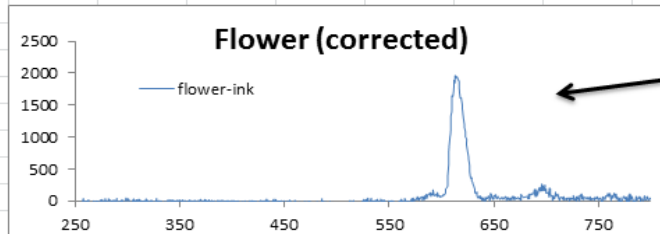
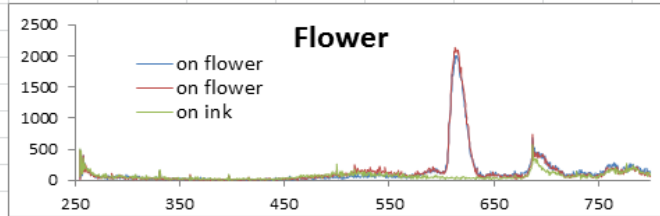




# SACOS Principle and Counterfeiting Measurements

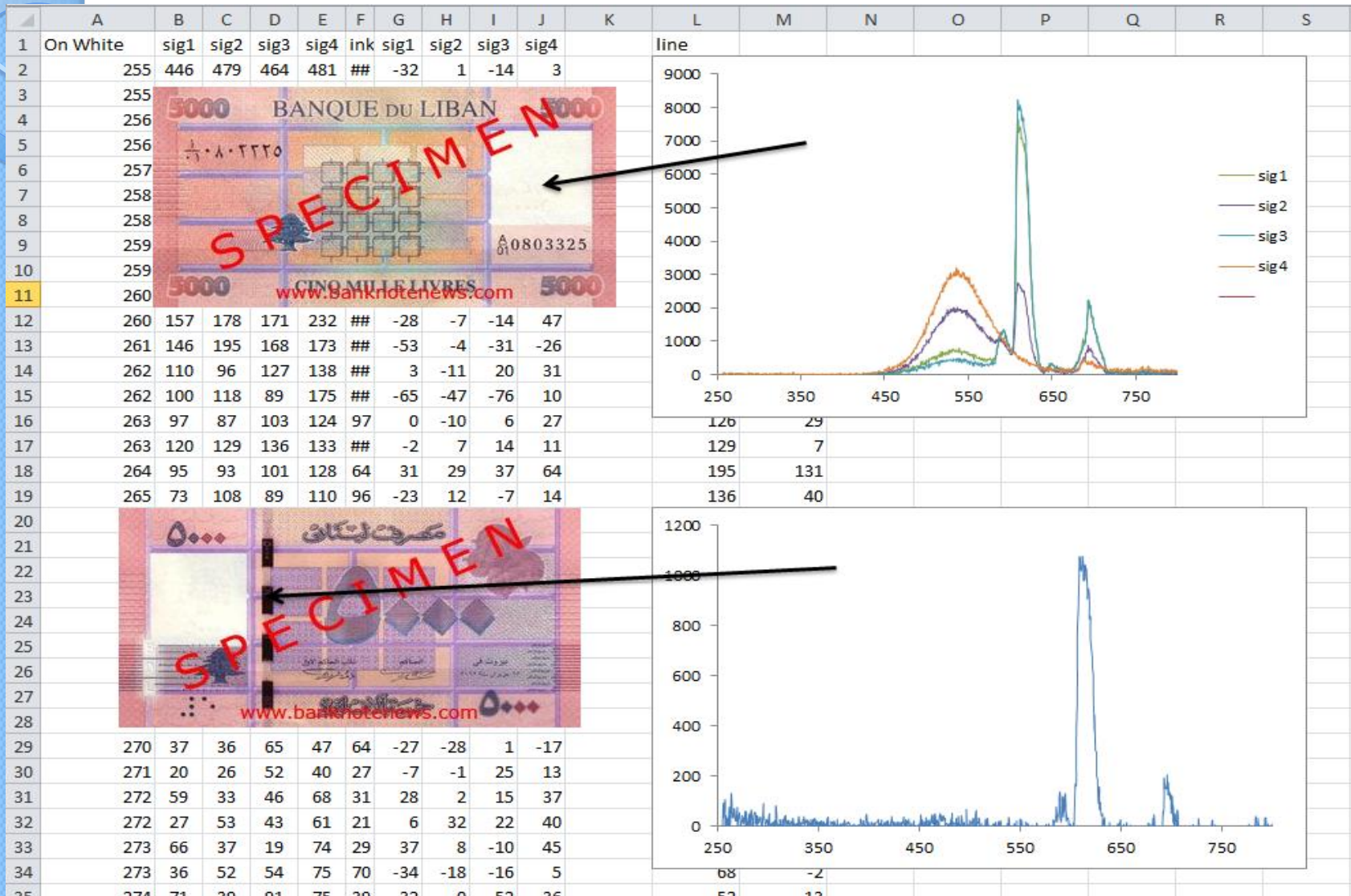
## New Applications to Explore (BANKNOTES)

	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
1	on flower	on ink	flower-	on whi	white-i	on whi	on white	face 2-ink													
2	481	508	-15	518	10	473	-35														
3	10	60	-30	26	-34	20	-40														
4	426	467	-88	419	-48	377	-90														
5	364	396	-76	388	-8	358	-38														
6	107	102	-28	113	11	84	-18														
7	400	361	42	435	74	388	27														
8	182	169	32	209	40	207	38														
9	136	219	-63	175	-44	204	-15														
10	260	283	4	303	20	253	-30														
11	137	197	-26	208	11	166	-31														
12	255	224	-27	220	-4	190	-34														
13	193	178	-2	229	51	227	49														
14	119	191	0	155	-36	140	-51														
15	132	165	1	192	27	160	-5														
16	133	175	-20	177	2	134	-41														
17	129	135	22	152	17	170	35														
18	164	182	-64	132	-50	71	-111														
19	72	184	-55	147	-37	174	-10														
20	104	139	-41	168	29	126	-13														
21	96	109	-19	149	40	101	-8														
22	92	94	-13	134	40	96	2														
23	95	136	-33	110	-26	69	-67														
24	57	81	3	94	13	79	-2														
25	75	93	-32	91	-2	65	-28														
26	51	101	-23	83	-18	85	-16														
27	59	92	-35	92	0	33	-59														
28	68	67	2	86	19	101	34														
29	84	88	-50	84	-4	72	-16														
30	59	62	-2	67	5	73	11														
31	66	91	-6	76	-15	69	-22														
32	25	74	-22	76	2	40	-34														
33	76	102	-49	95	-7	72	-30														
34	48	70	-41	51	-19	59	-11														
35	33	51	10	108	57	66	15														
36	38	59	11	100	41	44	-15														
37	30	68	0	65	-3	83	15														
38	46	73	-24	78	5	48	-25														
39	56	29	26	80	51	42	13														
40	55	98	-28	70	-28	47	-51														
41	78	74	-8	93	19	28	-46														



# SACOS Principle and Counterfeiting Measurements

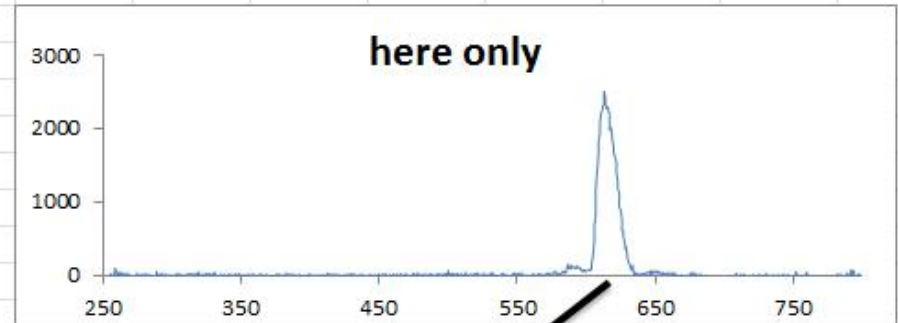
## New Applications to Explore (BANKNOTES)



# SACOS Principle and Counterfeiting Measurements

## New Applications to Explore (BANKNOTES)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Time - Plo Charge ink corrected																
2	255	445	442	3													
3	255	20	45	-25													
4	256	406	381	25													
5	256	355	354	1													
6	257	54	52	2													
7	258	314	323	-9													
8	258	131	114	17													
9	259	197	135	62													
10	259	271	173	98													
11	260	170	109	61													
12	260	152	174	-22													
13	261	202	169	33													
14	262	162	154	8													
15	262	134	155	-21													
16	263	121	85	36													
17	263	144	89	55													
18	264	111	126	-15													
19	265	75	78	-3													
20	265	93	71	22													
21	266	86	56	30													
22	266	57	71	-14													
23	267	90	107	-17													
24	268	61	86	-25													
25	268	108	74	34													
26	269	54	73	-19													
27	269	58	51	7													
28	270	57	77	-20													





# SACOS Principle and Application to Forensics

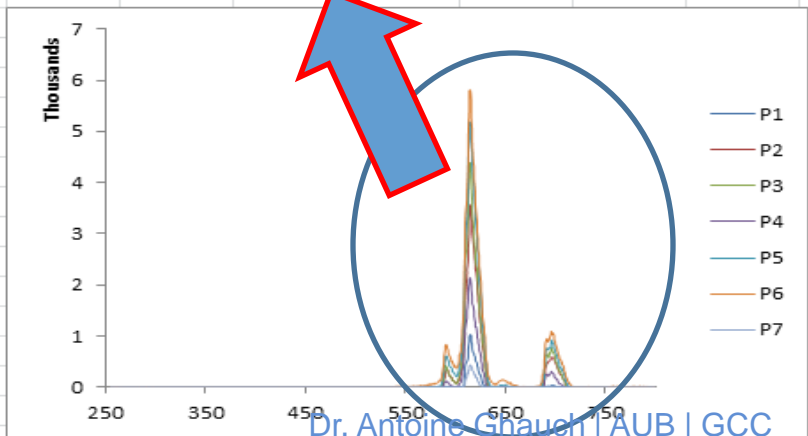
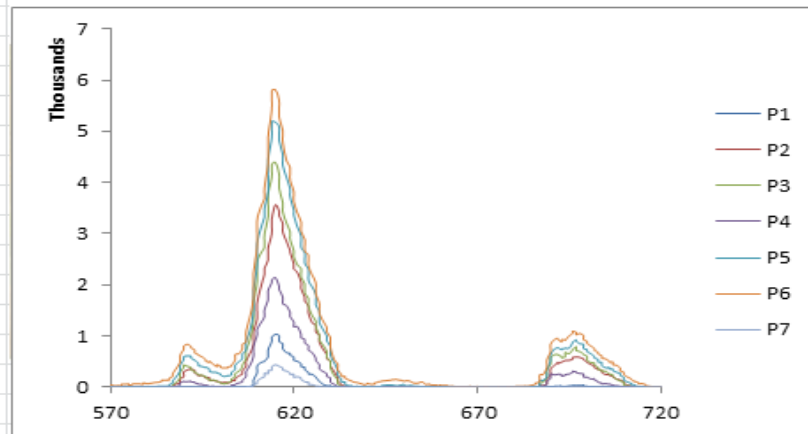
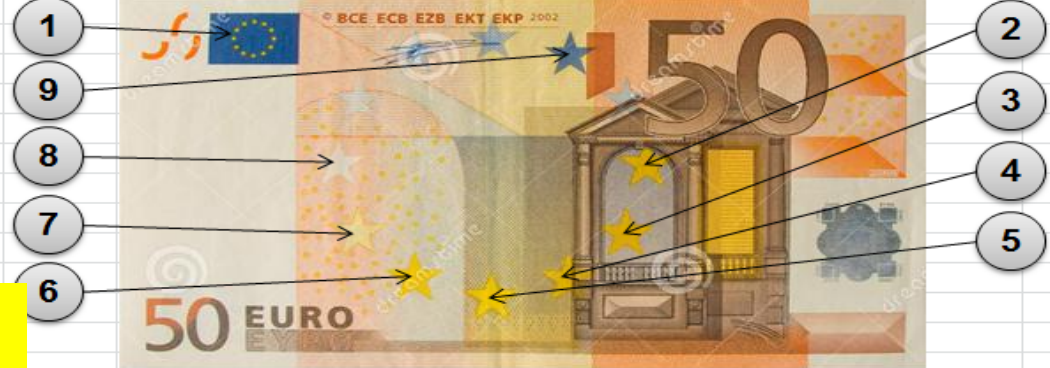
1	Wavelength	P1	P2	P3	P4	P5	P6	P7	P8	P9
2	255	0	0	0	0	0	0	0	0	
3	255	0	0	0	0	0	0	0	0	
4	256	0	0	0	0	0	5	0	0	
5	256	0	0	0	0	0	2	3	0	
6	257	0	0	0	0	0	0	0	0	
7	258	0	0	0	0	2	6	0	0	
8	258	0	0	0	0	0	9	0	0	
9	259	0	0	0	0	0	7	0	0	
10	259	0	0	0	0	0	3	0	0	
11	260	0	0	0	0	0	3	0	2	

Quantification, Quality control, Counterfeiting

16	263	0	0	0	2	0	4	0	0	
17	263	0	0	0	0	0	7	0	0	
18	264	0	0	0	0	1	2	0	0	
19	265	0	0	0	1	0	1	0	0	
20	265	0	0	0	0	0	2	0	0	
21	266	0	0	0	0	0	7	0	0	
22	266	0	0	0	0	0	1	0	0	
23	267	0	1	0	0	0	6	0	0	
24	268	0	0	0	0	0	0	0	0	
25	268	0	0	0	0	0	2	0	0	
26	269	0	0	0	2	0	4	0	0	

Film thickness

28	271	0	0	0	0	0	1	0	0	
29	271	0	0	0	0	0	0	0	0	
30	271	0	0	0	0	0	1	0	0	
31	272	0	0	0	1	0	4	0	0	
32	272	0	0	0	0	0	1	0	0	
33	273	0	0	0	0	0	1	0	0	
34	273	0	0	0	0	0	1	0	0	
35	274	0	0	0	0	0	0	0	0	
36	275	0	0	0	0	2	3	0	0	
37	275	0	0	0	0	0	1	0	0	
38	276	0	0	0	0	0	0	0	0	
39	276	0	0	0	0	0	0	0	0	
40	277	0	0	0	0	0	2	0	0	
41	278	0	0	0	0	0	5	0	0	
42	278	0	0	0	0	0	0	0	0	
43	279	0	0	0	0	0	0	0	0	
44	279	0	0	0	0	0	0	0	0	
45	280	0	0	0	0	2	2	0	0	


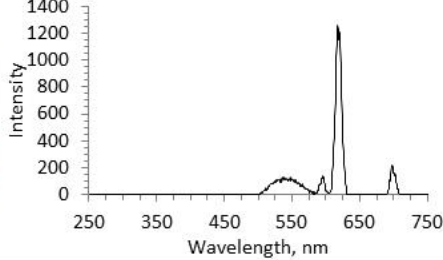

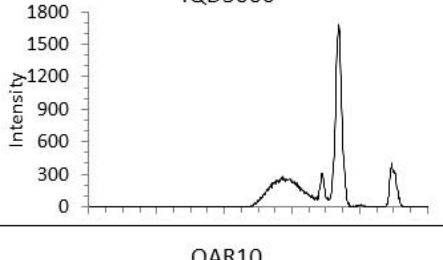

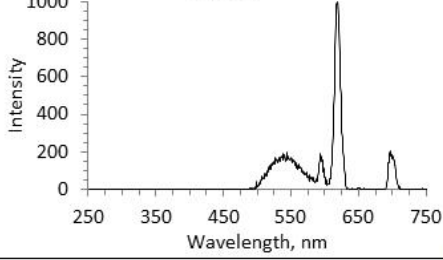




# SACOS Principle and Application to Forensics

## New Applications to Explore (BANKNOTES)

**Table 1: Summary of select banknotes authenticated by SACOS with unique spectral fingerprints**

Country	Banknote sample	Spectrum
Bahrain (BHD)		<p>BHD1</p>  <p>Intensity</p> <p>Wavelength, nm</p>
IRAQ (IQD)		<p>IQD5000</p>  <p>Intensity</p> <p>Wavelength, nm</p>
Qatar (QAR)		<p>QAR10</p>  <p>Intensity</p> <p>Wavelength, nm</p>

# SACOS Principle and Application to Forensics

## New Applications to Explore (BANKNOTES)



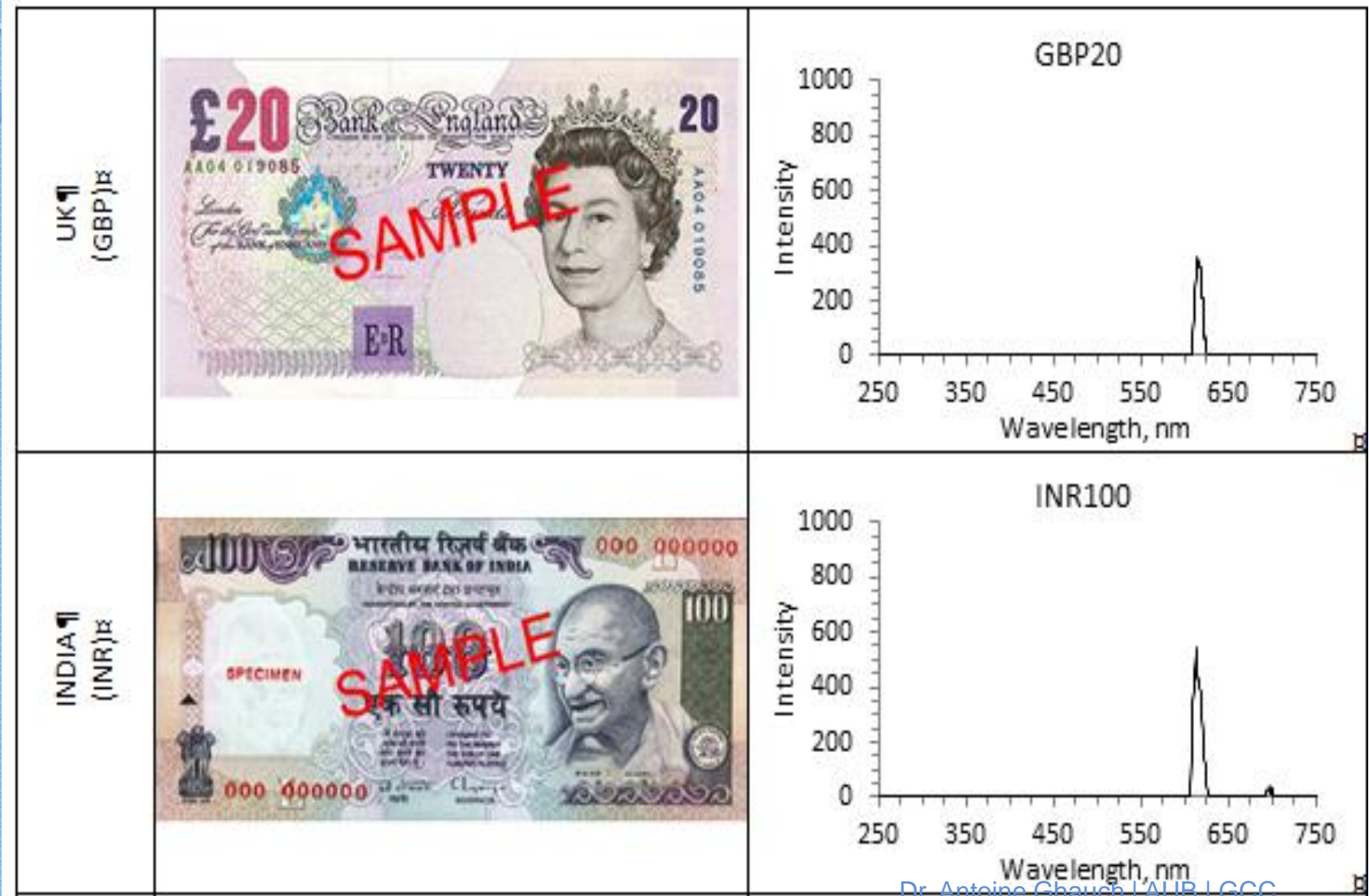
## Fake \$100 Bills Eluded Detection With Rare Quality



A counterfeit specialist with the U.S. Secret Service demonstrates inspecting a counterfeit \$100 bill under a microscope in the counterfeit specimen vault room at the Secret Service headquarters in Washington, D.C. Photographer: Andrew Harrer/Bloomberg

# SACOS Principle and Application to Forensics

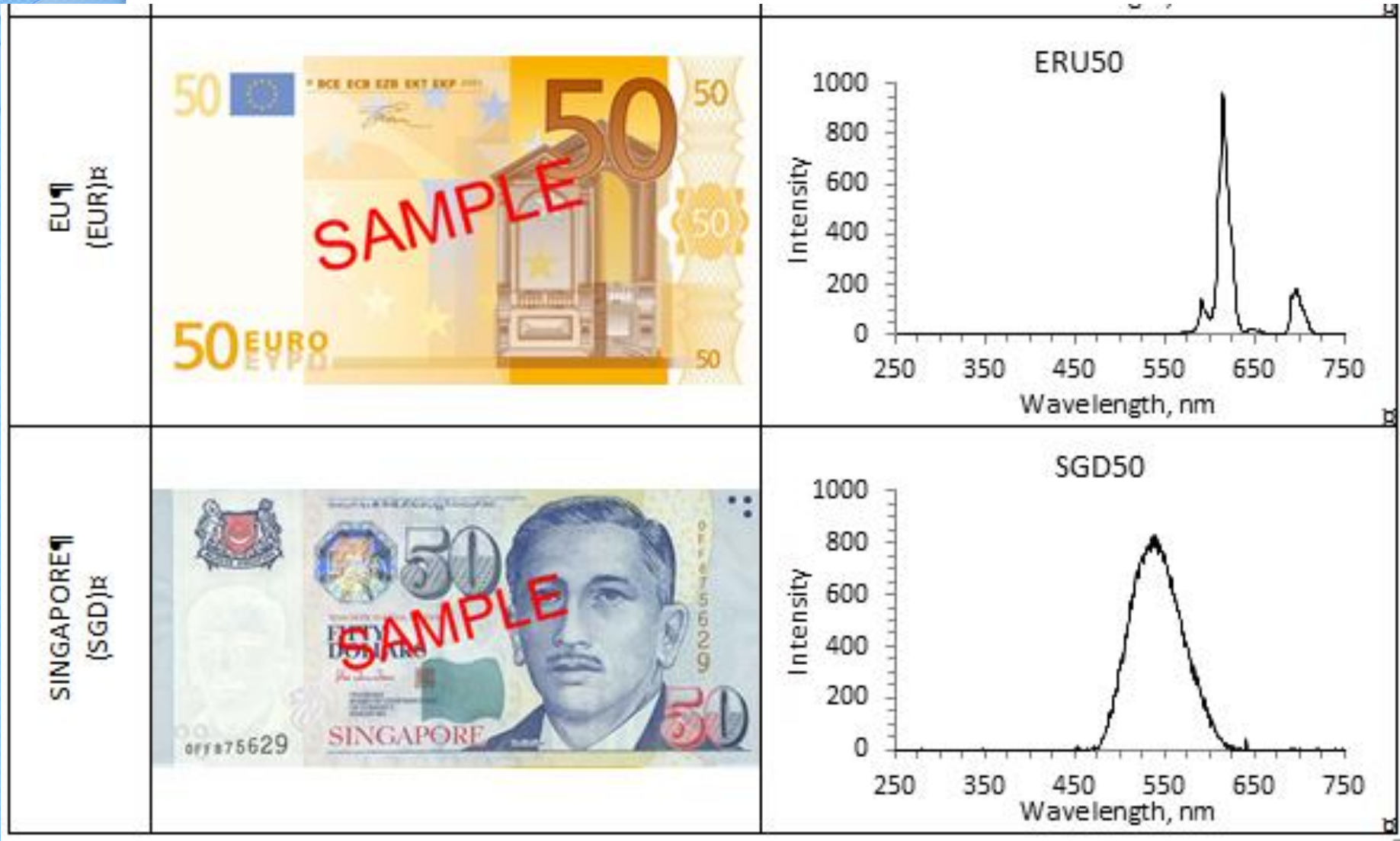
## New Applications to Explore (BANKNOTES)





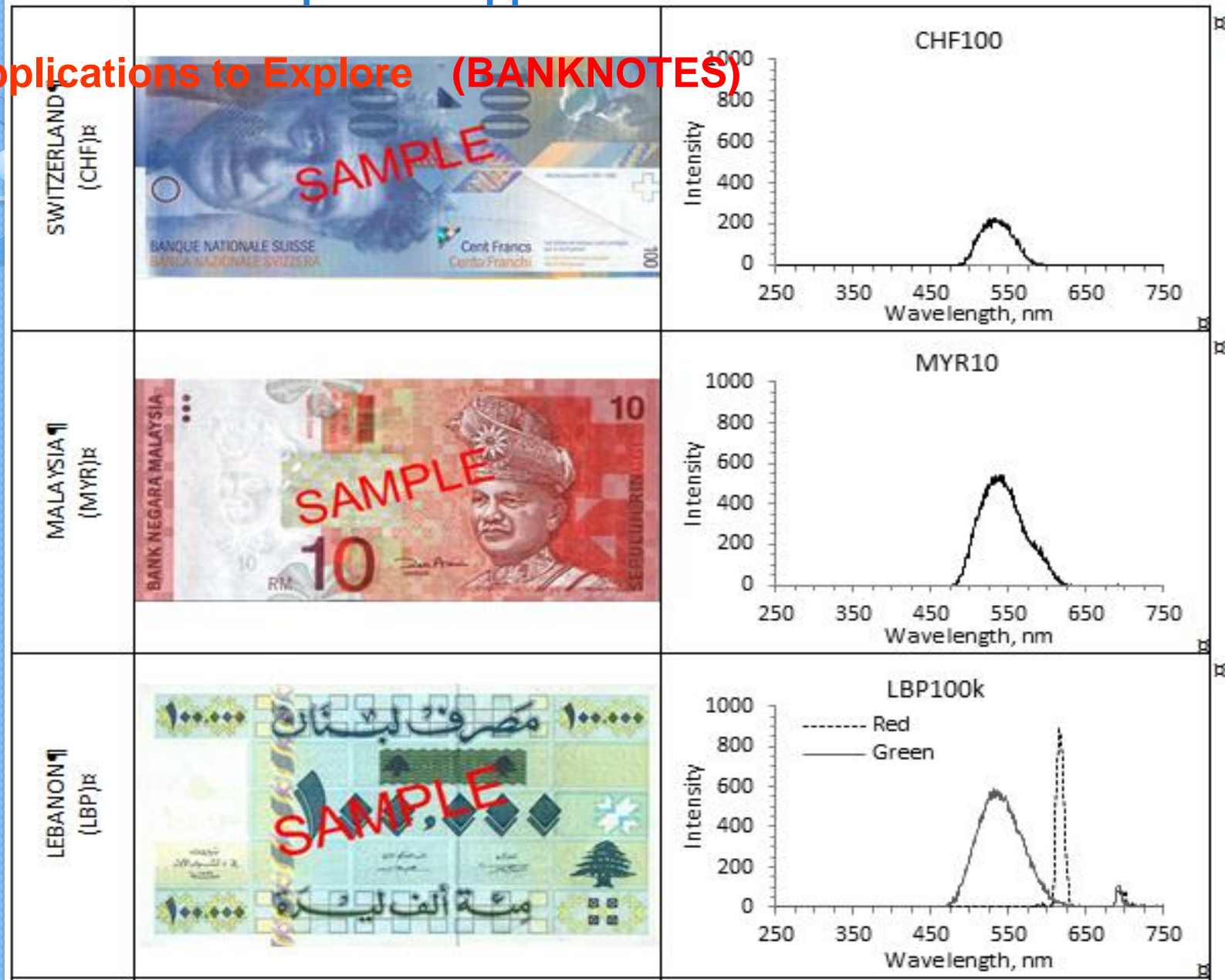
# SACOS Principle and Application to Forensics

## New Applications to Explore (BANKNOTES)



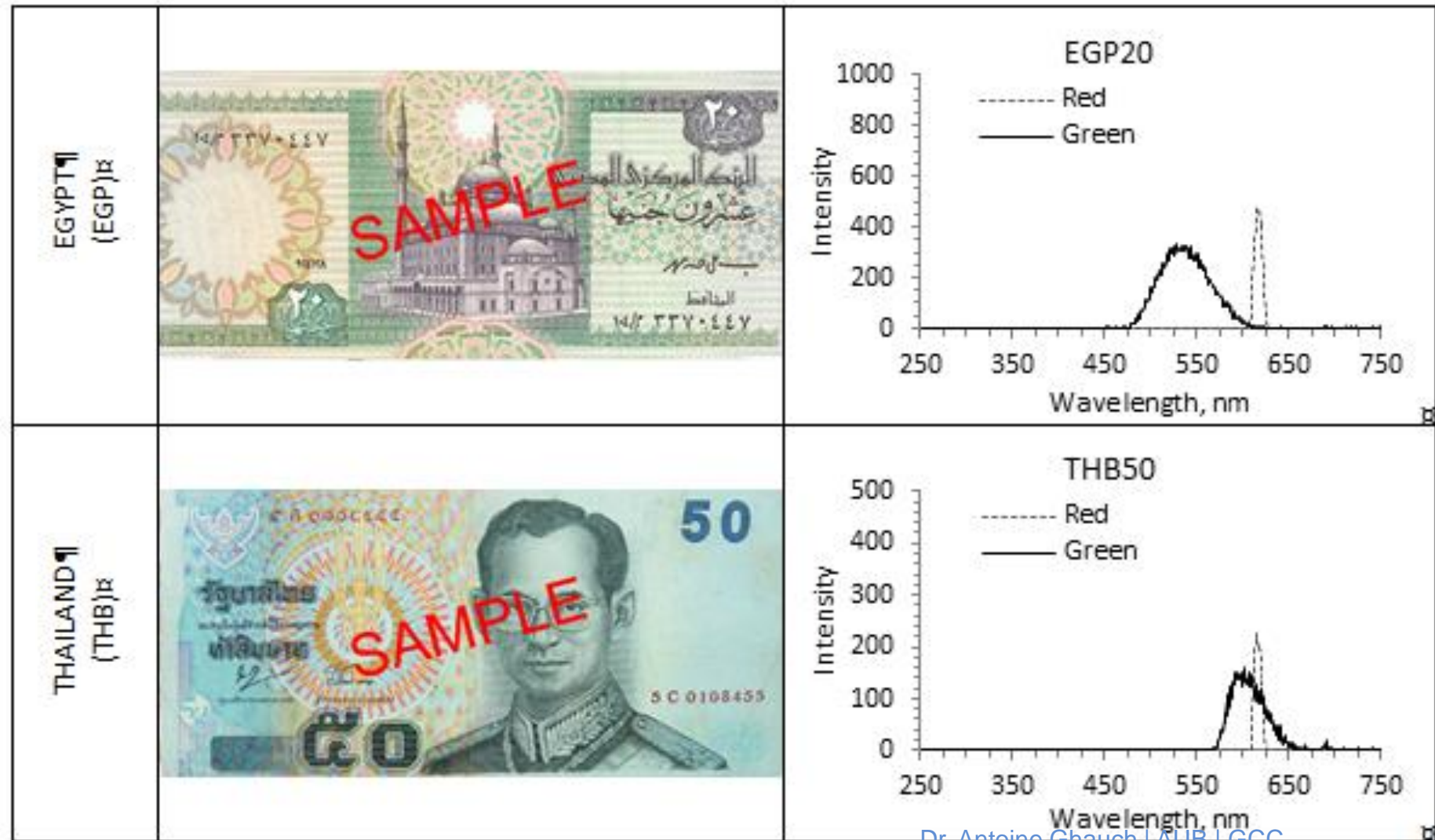
# SACOS Principle and Application to Forensics

## New Applications to Explore (BANKNOTES)



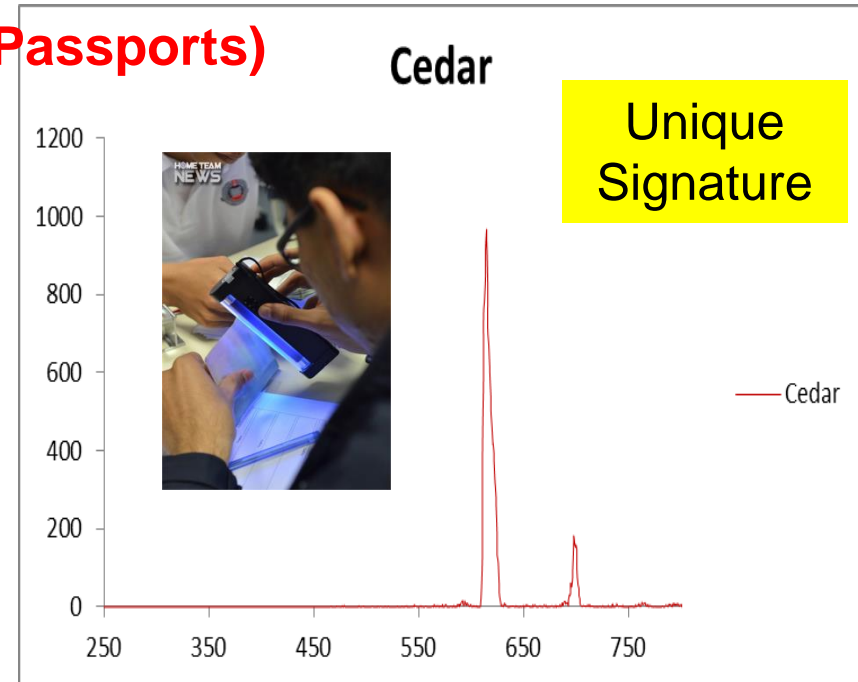
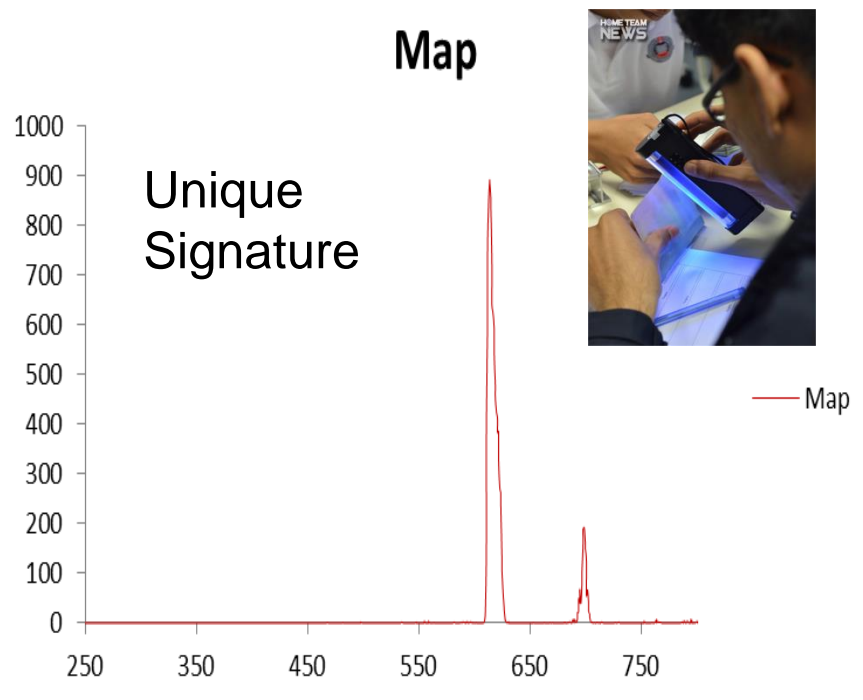
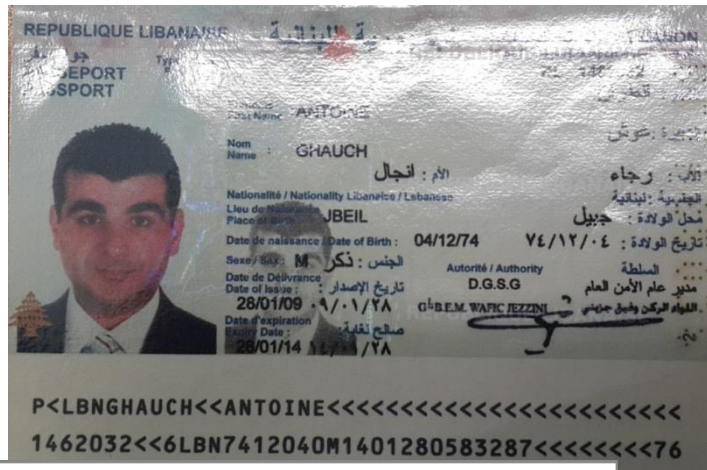
# SACOS Principle and Application to Forensics

## New Applications to Explore (BANKNOTES)

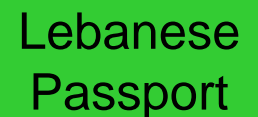




## New Applications to Explore (Passports)

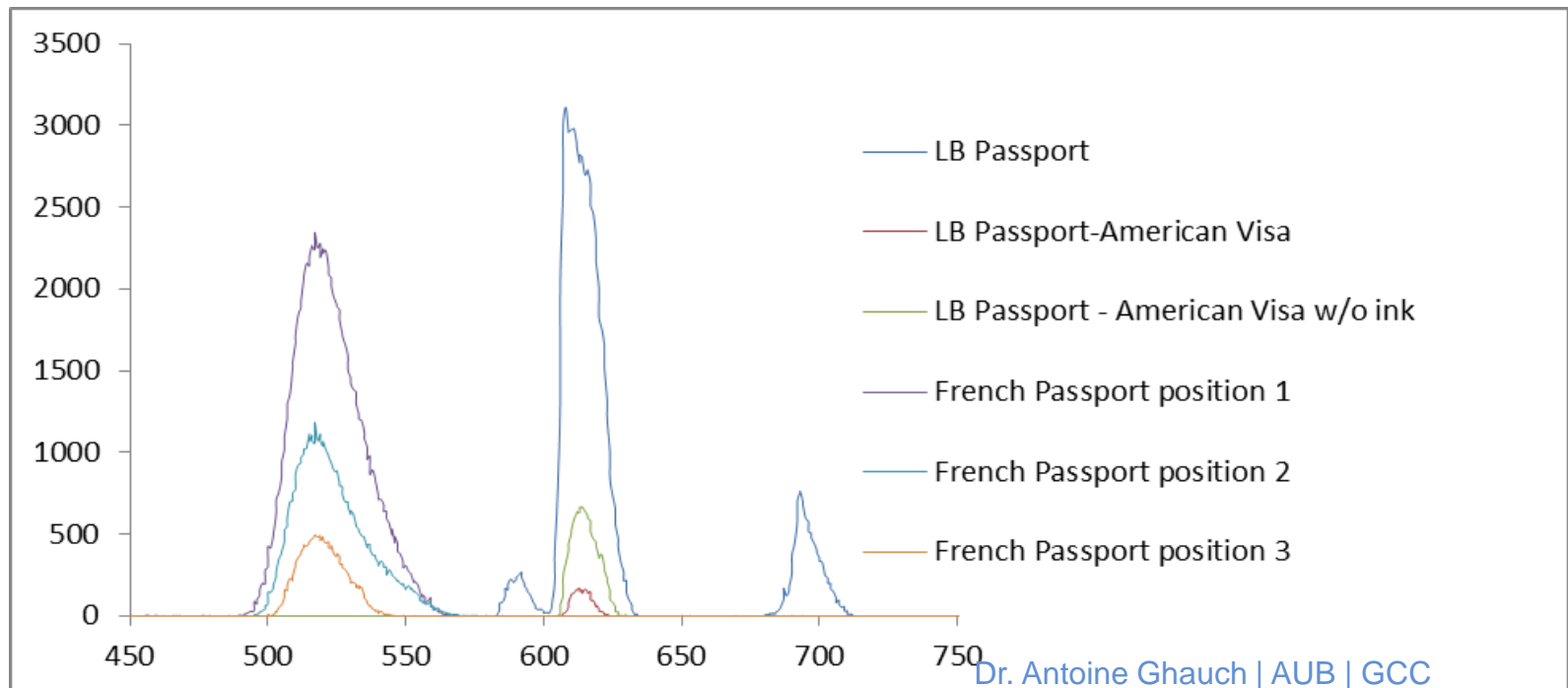


## New Applications to Explore (VISA)



# SACOS Principle and Counterfeiting Measurements

## New Applications to Explore (VISAS)





# SACOS Principle and Counterfeiting Measurements

## Planet NI Program Case Study



### Detecting Organic Contaminants Using a Spectroscopy-Based Device

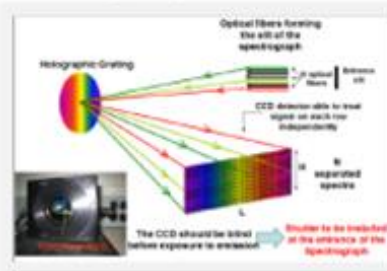


Figure 1. Imaging System

"Through the Planet NI program, we closely collaborated with NI engineers to precisely define our DAQ device and user interface development needs. NI also recommended that we work with a postdoctoral fellow specializing in LabVIEW and NI technology. His proficiency with the NI platform, along with NI engineer consulting and technical support, played an important role in this project."

- Dr. Antoine Ghauch, Department of Chemistry, American University of Beirut

#### The Challenge:

Developing a real-time, nondestructive system to monitor and control water pollution, counterfeiting, and environmental studies.

#### The Solution:

Combining the benefits of a USB-6251 DAQ device and LabVIEW to develop a spectroscopy-based device for detecting organic contaminants in effluents, dopants in biological samples, and designated compounds used in counterfeiting processes.

#### Author(s):

Dr. Antoine Ghauch - Department of Chemistry, American University of Beirut

Dr. Ali Ammouri - American University of Beirut

Dr. David Sedlak - University of California-Berkeley


#### American University of Beirut



Founded in 1866, the American University of Beirut bases its educational philosophy, standards, and practices on the American liberal arts model of higher education. A teaching-centered research university, AUB has approximately 700 instructional faculties and a student body of nearly 8,000 students. The University encourages freedom of thought and expression and seeks to graduate men and women committed to creative and critical thinking, life-long learning, personal integrity, civic responsibility, and leadership.

### Detecting Organic Contaminants and Counterfeited Goods

The world faces many problems, including water pollution, counterfeiting, and environmental destruction. Monitoring and controlling such issues is a priority, as they are directly related to society, particularly human health. Existing monitoring and control devices, although good at identifying a pollution problem or counterfeited goods, are limited in response



# Validation of the Developed Technologies under USAID-PEER Award 1-84 (2012-2015) then 5-18 (2016-2020)

Through Stakeholders

National

International

# CONTACTS = SEEK FOR INTERNATIONAL PLAYERS IN THE FIELD OF DEVELOPING NEW SECURITY FEATURES FOR PRINTING

## PEER Year 3 (2015), ... Starting the search for stakeholders, industrials and investors

1. 2015: Radece Visit: Workshop # 1 on April 2<sup>nd</sup>.
2. 2015: AUB Visit: Preparation of Agreement for Technology Transfer on June 22 (M. Igor Rakusa and M. Georges Berberi)
3. 2015: USAID and NAS headquarters at Washington DC
4. 2015: Blum Center at UC-Berkeley (May 18)
5. 2015: Radece Visit; Workshop # 2 on October 1<sup>st</sup> to extend R&D toward additional patents.
6. Invention valuation done by third party upon OGC request.
7. 2016: Search for Additional stakeholders AUB visit on February 22<sup>nd</sup> by SSP IDENT owner and CEO (M. Michael Proda and M. Georges Berberi).
8. 2017: Visiting the GWC at Wisconsin and Georgetown University at Washington DC for more opportunities with industrialists.
9. 2018: Visiting Interpol at LYON-FRANCE
10. 2018: Visiting HORIBA – PARIS / NEW JERSEY



## Research Impact and Societal Outcomes

### European / Lebanese Stakeholders

#### Slovenia interests

- 1- Radece papier group
- 2- National Institute of Chemistry
- 3- Pulp and Paper Institute
- 4- National Forensic Laboratory



**Workshop and  
Scientific Visit 1-3  
April, 2015**

## Research Impact and Societal Outcomes

### European / Lebanese Stakeholders



- 1- Radece papir group
- 2- National Institute of Chemistry
- 3- Pulp and Paper Institute
- 4- National Forensic Laboratory

Central Banks,  
EU Police,  
Ministries



## Research Impact and Societal Outcomes

### European / Lebanese Stakeholders

Workshop on April 2<sup>nd</sup>, 2015 at  
Radece Papir Group Slovenia

Slovenia interests

- 1- Radece papir group
- 2- National Institute of Chemistry
- 3- Pulp and Paper Institute
- 4- National Forensic Laboratory



VSC6000 USER, Natasa, VSC6000/HS, Serial Number 60717  
11:59:52 16/04/2015 Lights=Flood, Longpass=VIS, Mag=1.51  
Auto Exposure (Integration=69ms, Iris=49%), Brightness=60, Gamma=Off, Imaged width=214.57 mm

Central Banks,  
Ministries



VSC6000 USER, Natasa, VSC6000/HS, Serial Number 60717  
12:01:00 16/04/2015 Lights=312nm Ultra Violet, Longpass=VIS, Mag=1.51  
Integration=595ms, Iris=90%, Brightness=60, Gamma=On, Imaged width=214.57 mm



## Research Impact and Societal Outcomes

### European / Lebanese toward international stakeholders

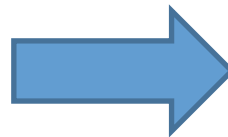


VSC6000 USER, Natasa, VSC6000/HS, Serial Number 60717  
11:59:52 16/04/2015 Lights=Flood, Longpass=VIS, Mag=1.51  
Auto Exposure (Integration=69ms, Iris=49%), Brightness=60, Gamma=Off, Imaged width=214.57 mm

- 31/2009 (100 eur, offset, UV dye)
- 4138/2010 (200 eur, offset, UV dye)
- 6759/2006 (500 eur, offset, UV dye)
- 2937/2003 (500 eur, offset, UV dye)
- 4018/2007 (20 eur, offset, UV dye)
- 5638/2009 (50 eur, offset)
- 4205/2003 (50 eur, offset)
- 4725/2003 (5 eur, inkjet, UV magenta)
- 2127/2011 (10 eur, inkjet)
- 4634/2007 (20 eur, inkjet)
- 1904/2013 (50 eur, inkjet, UV magenta)
- 7133/2007 (500 eur, inkjet)
- 4214/2005 (100 eur, toner)
- 5164/2003 (100 eur, toner, UV dye)
- 174/2003 (200 eur, toner, UV dye)

I attached pictures in normal light, UV and transmitted  
If you need anything else let me know.  
Sincerely,

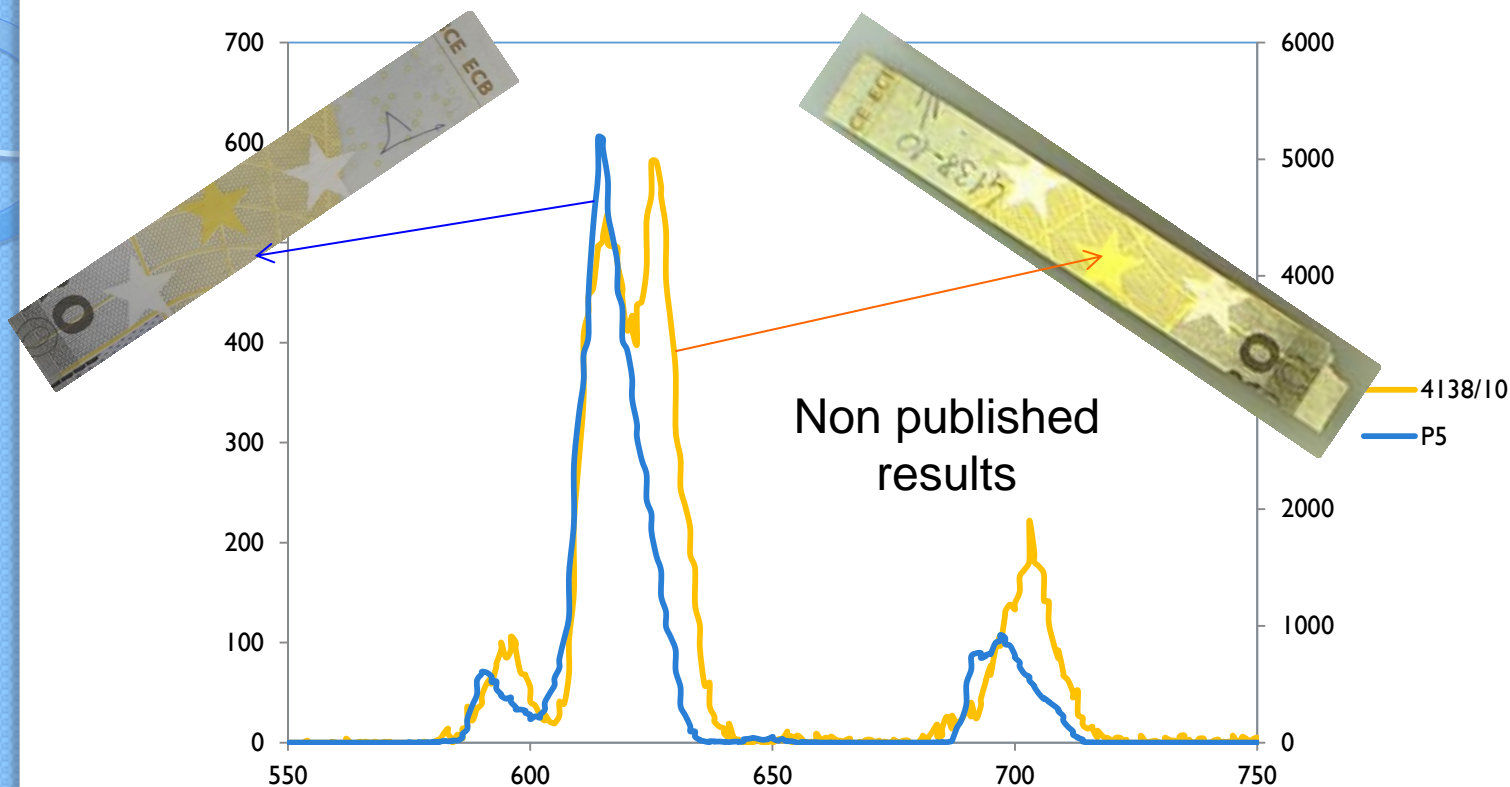
# New Horizons



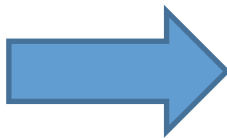
## Development of New Dyes | From Classical to Novel Approach for Securing Papers/Goods and Detecting Counterfeiting

## Research Impact and Societal Outcomes

### European / Lebanese toward international stakeholders



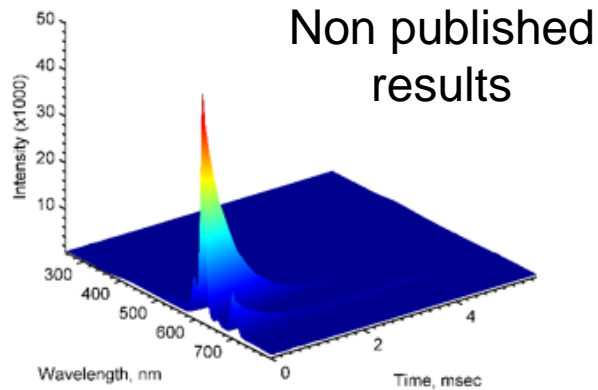
2015 Results



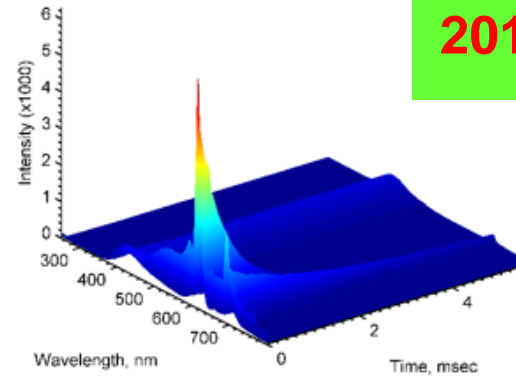
Fake vs Authentic  
200 Euros Banknote



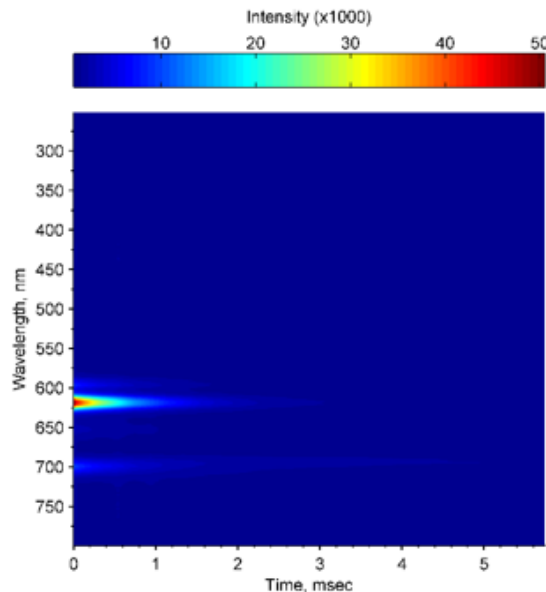
## Research Impact and Societal Outcomes



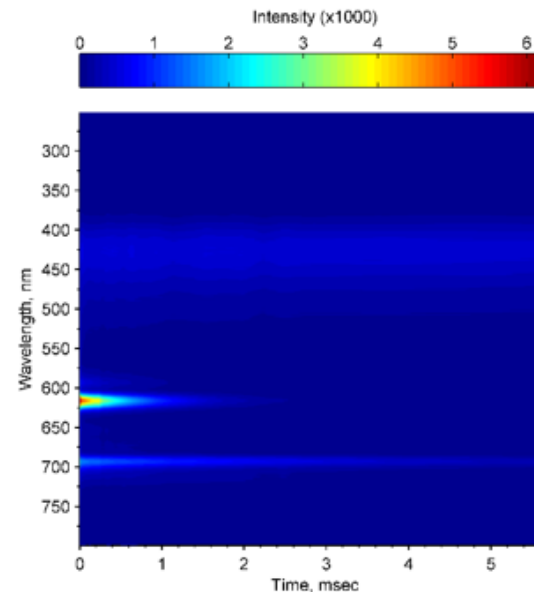
(a)



(b)



(c)



(d)

Figure 1. Unique 3D phosphorescence fingerprint of (a) Authentic EUR200 and (b) Fake EUR200 and unique 2D phosphorescence fingerprint of (c) Authentic EUR200 and (d) Fake EUR200

2017 Results

ANN

RTP lifetime

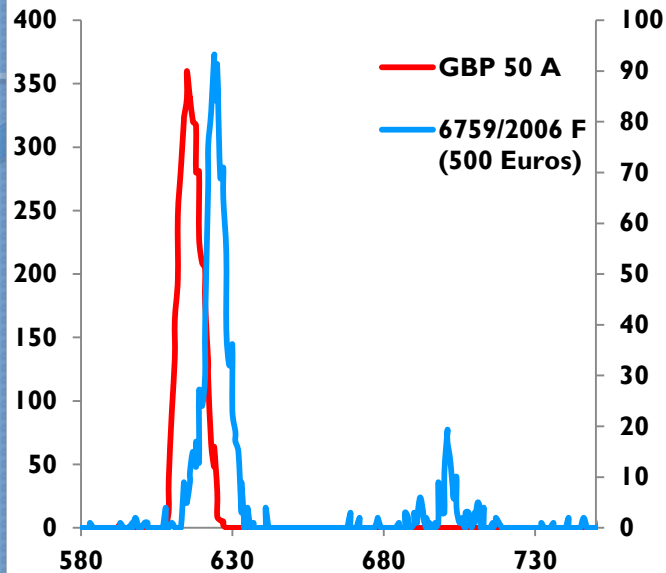
RTP frequency

RTP amplitude

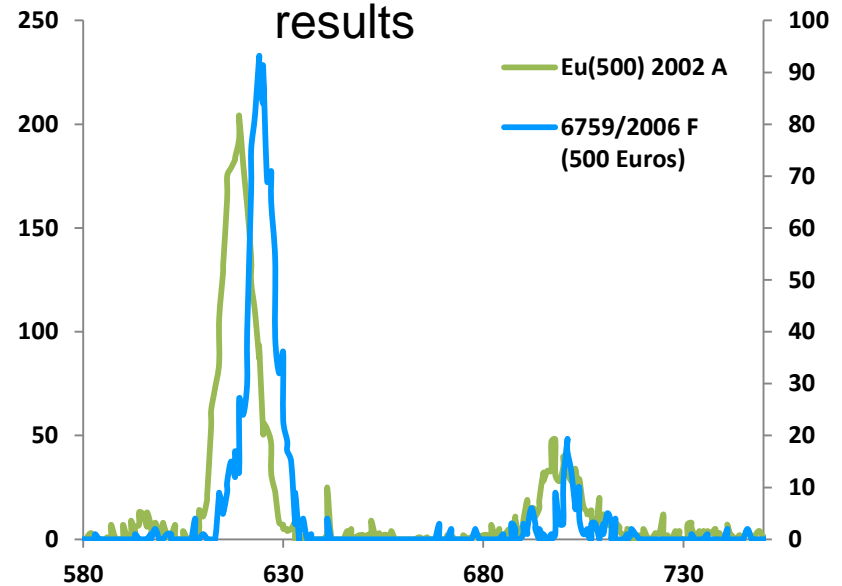


## Research Impact and Societal Outcomes

### European / Lebanese toward international stakeholders



Non published results

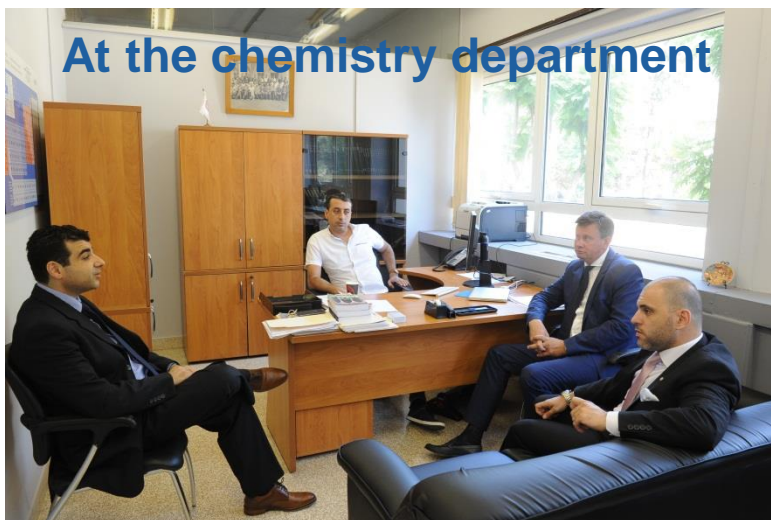


**Fake vs Authentic 500 Euros Banknote**



# CONTACTS

## AUB – Visit by Radece Papir Group CEO and MD





# CONTACTS

## AUB – Visit by Radece Papir Group CEO and MD



At the Dean's Office exploring mutual interest

With FAS Dean Patrick McGreevy



At the OGC - TTU

With Dr. Fadia Homaidan/OGC Director

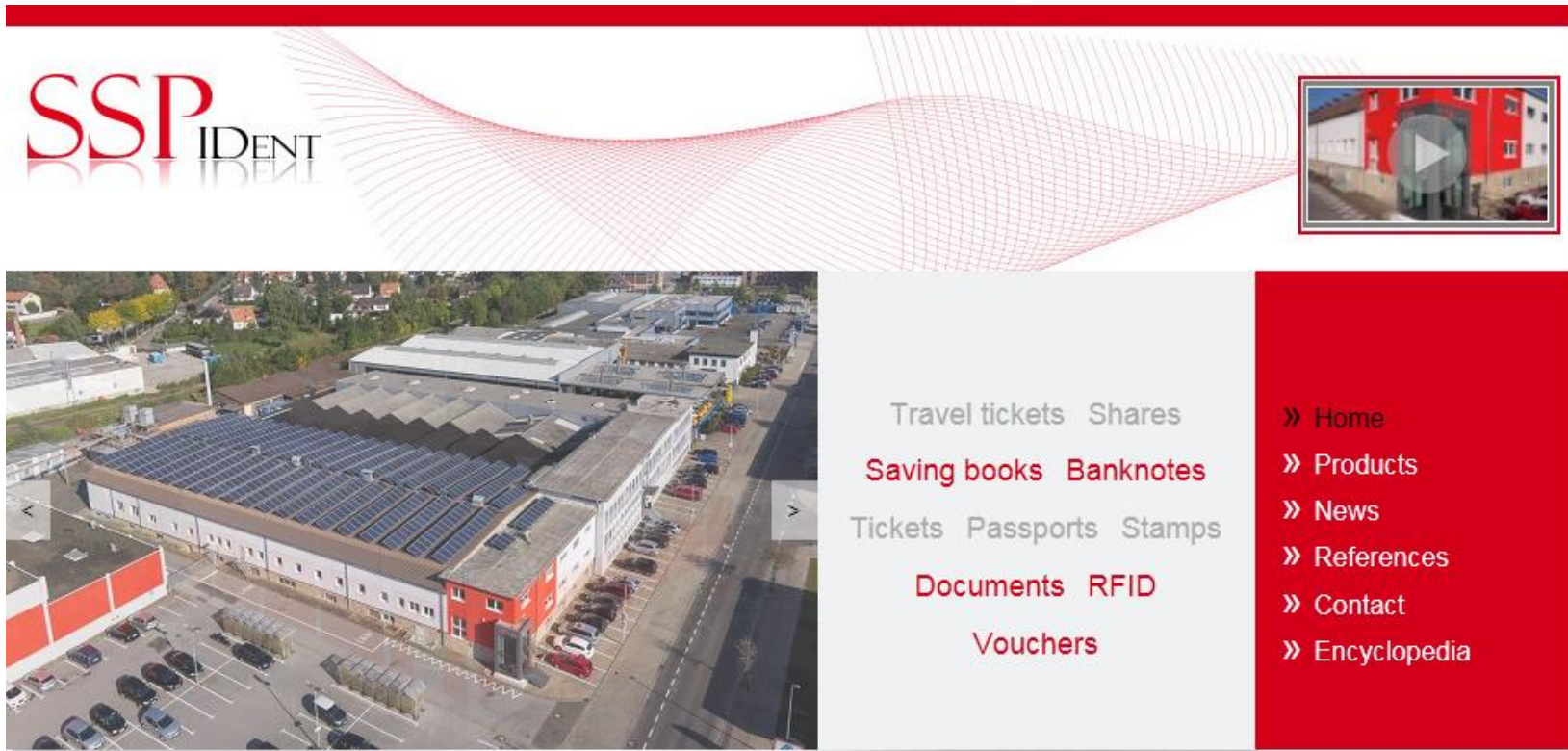


Dr. Antoine Ghauch | AUB | GCC



# Additional Contacts (New Stakeholders)

AUB – Visit by SSP IDent February 22, 2016



## Welcome to SSP IDENT

SSP IDENT GmbH is one of three high security printing centres in Germany licensed to produce banknotes and passports. The company is also one of the leading travel ticket printers in Europe.

Together with our customers, we have been developing individual print and media products for over 140 years.



## Additional Contacts (New Stakeholders)

**AUB – Visit by SSP IDent February 22, 2016**



Chemistry Chairperson



SACOS Demonstration



# Additional Contacts (New Stakeholders)

**AUB – Visit by SSP IDent February 22, 2016**



With AUB  
Provost/Chancellor

With the  
OGC Director





No geographic  
Limitations !

## Research Impact and Societal Outcomes

### Development of New Dyes | From Classical to Novel Approach for Securing Papers/Goods and Detecting Counterfeiting

CRAIN'S DETROIT BUSINESS

NEWS AWARDS EXTRAS DATA BLOGS / OPINION EVENTS MULTIMEDIA

TOP STORIES ▾ | ○ Grace Hsia: Driven by startup life, giving back

Brand strategy. Advertising. Design. »

**FACTORY**

December 08, 2014 4:01 p.m. UPDATED 12/8/2014

#### Counterfeit shoes, purses, clothing seized from Woodward Avenue shop in Detroit

By Associated Press



SHARE

Crime/Courts



MICHIGAN MORNING NEWSLETTER

Get a roundup of important news that happens each day.

SUBMIT

Brand strategy.  
Advertising.  
Design.

» Learn more

**FACTORY**

Legitimately good and  
worthy products are all  
around us. But folks who

**TAG for  
Luxury Goods**

**Luxury Clothes**

**Luxury Shoes**

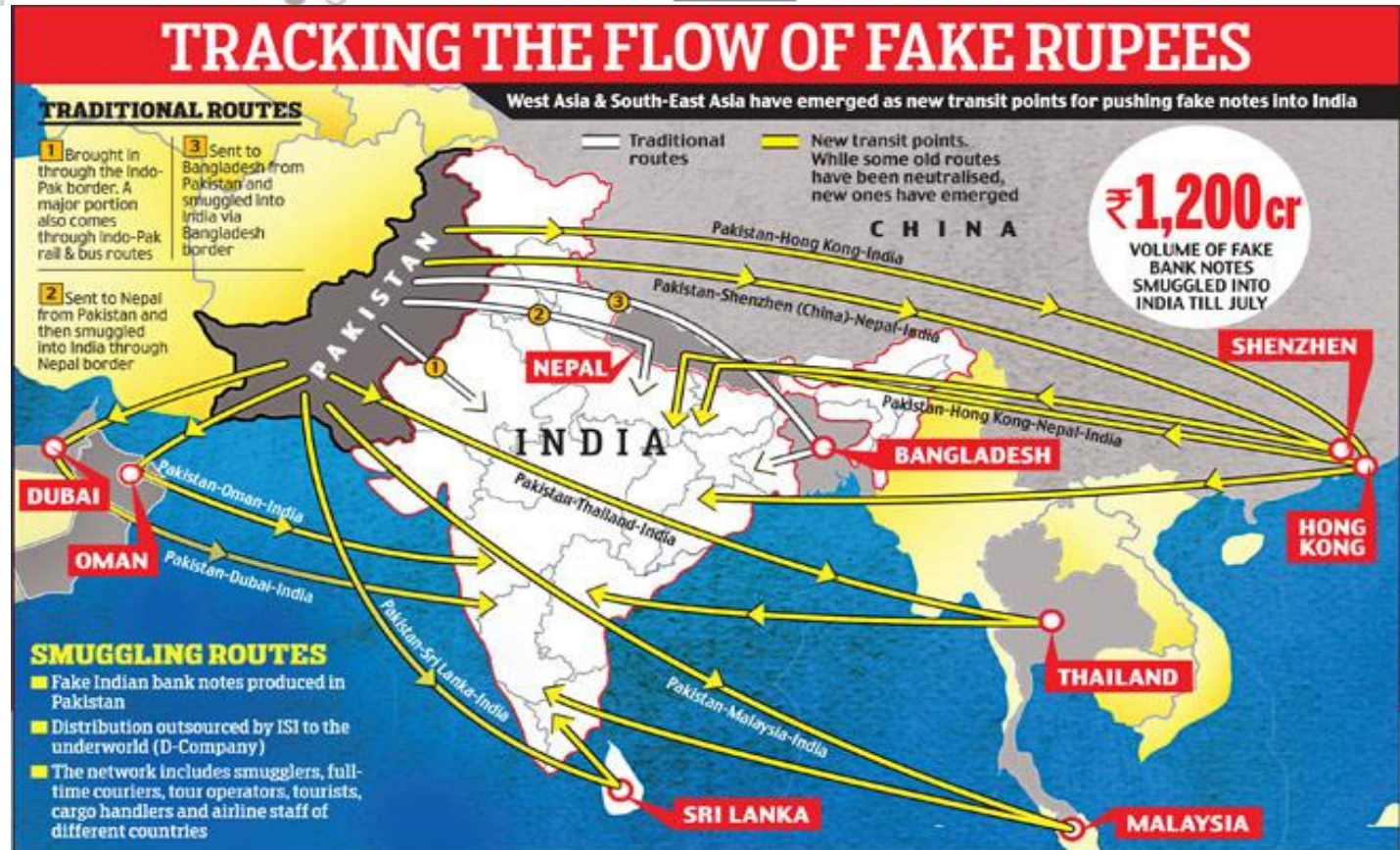


**Tracking down counterfeit merchandise, Saving Money,  
Improving Control and Enhancing Customs and Police  
Border Efficiency**

Dr. Antoine Ghauch | NAS | USAID

## Research Impact and Societal Outcomes

### Development of New Dyes | From Classical to Novel Approach for Securing Papers/Goods and Detecting Counterfeiting





# No geographic Limitations !

[Home](#) » [News](#) » [Greater Manchester News](#) » [Manchester](#)

## Dr. Antoine Ghauch | AUB | GCC



## Research Impact and Societal Outcomes

YouTube

LB



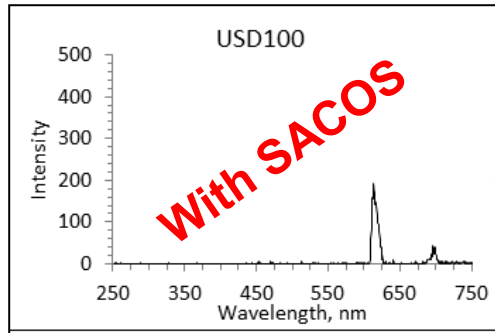
Published on Feb 1, 2014



1:05 / 1:52

A Man Producing Counterfeit NEW \$100 bills arrested ( LIVE NEWS )

# Fake \$100 Bills Eluded Detection With Rare Quality



A counterfeit specialist with the U.S. Secret Service demonstrates inspecting a counterfeit \$100 bill under a microscope in the counterfeit specimen vault room at the Secret Service headquarters in Washington, D.C. Photographer: Andrew Harrer/Bloomberg

# At Dubai Airport



How forged passports are caught in UAE  
923,444 views

[https://www.youtube.com/watch?v=EjKBWHhBi\\_8](https://www.youtube.com/watch?v=EjKBWHhBi_8)



This locker has  
passport specimens  
from every country

How forged passports are caught in UAE  
4.2K 459 SHARE SAVE



At least  
**70%**  
of the counterfeit  
passports are  
identified with  
this machine

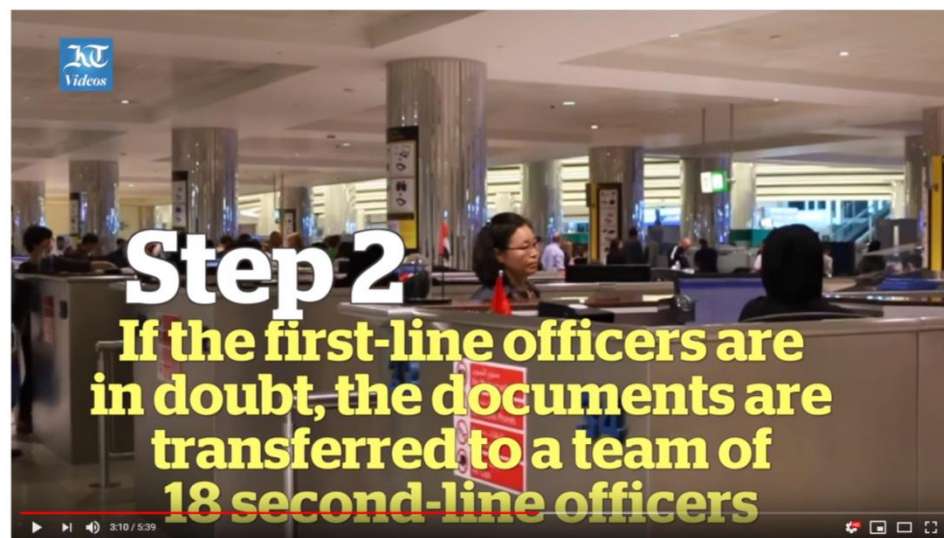
How forged passports are caught in UAE  
923,444 views



These are used  
as samples for  
comparing and  
examining your  
passport

Aqil Ahmad Al Najjar,  
consultant document examination center





**Number of forged documents detected in 2016**

**Fake passports: 657**

**Altered passports: 21**

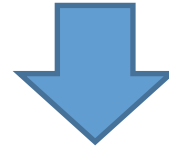
**Fraud impersonation cases: 391**

[https://www.youtube.com/watch?v=EjkbWWhhBi\\_8](https://www.youtube.com/watch?v=EjkbWWhhBi_8)

## Research Impact and Societal Outcomes

**Development of New Dyes | From Classical to Novel Approach for Securing Papers/Goods and Detecting Counterfeiting**

### **SOCIETAL OUTCOMES**



Sgt. Rick Ishitani, head of the Los Angeles Police Department Economic Crimes Unit.

"We notice that several gang members, organized crime and some terrorist groups are associated with distributing, manufacturing counterfeit goods. **Now all this money is funding other criminal activities. That's why we're in this.**

It's not so much the Rolex, Gucci, the Chanel. They are technically our victims, **but the real mission is to take down criminals.**"

# Future Development to help improving security features

## SCIENTIFIC QUESTIONS



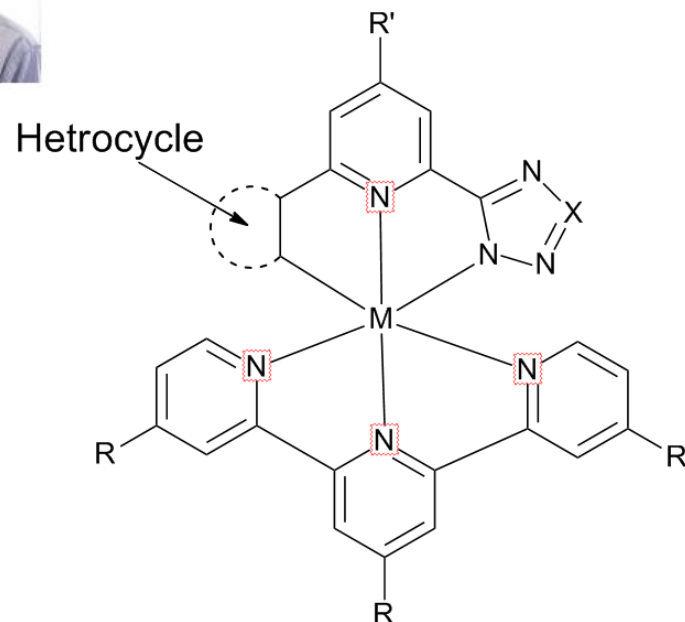
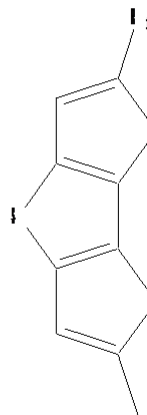
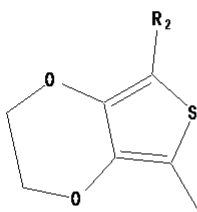
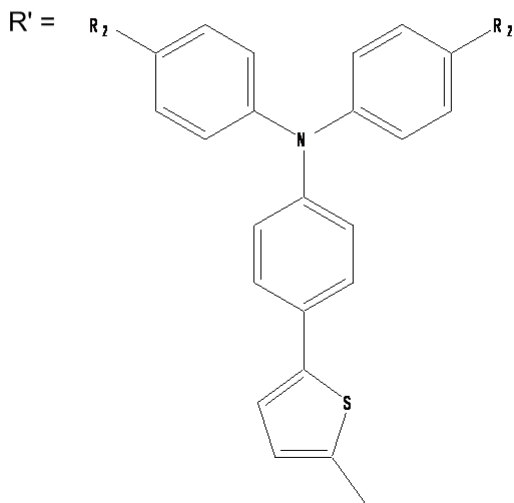
Can we develop special dyes for improving security features of papers? **YES !**

**Interdisciplinary Approach:  
Analytical Chemistry Division**



**Organic Chemistry  
Division at AUB: Dr.  
Tarek Ghaddar**

M = metal  
X = N, CCF<sub>3</sub>  
R = H, COOH  
Heterocycle = phenyl, tetrazole, pyrazole, triazole...

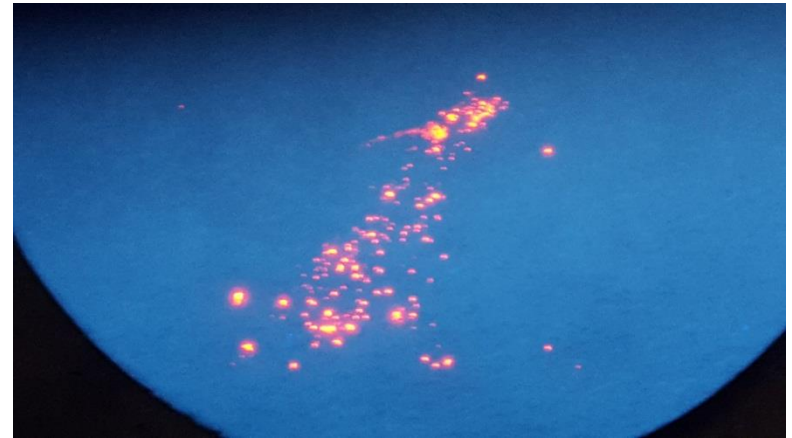




## RTP-Dyes Synthesis

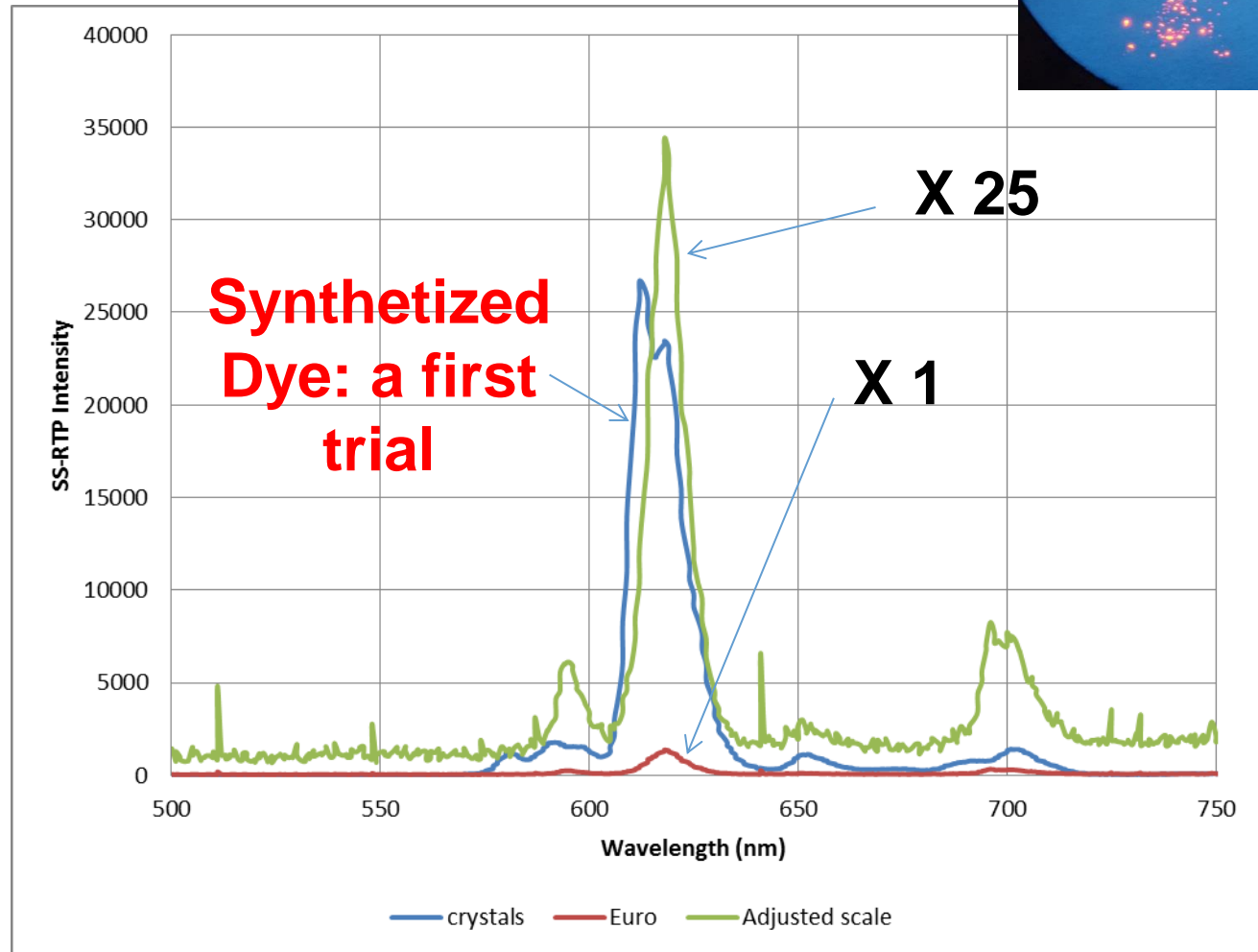


First synthesized crystals just done on Monday September 29, 2015.



Room Temperature Phosphorescence of Crystals upon UV irradiation

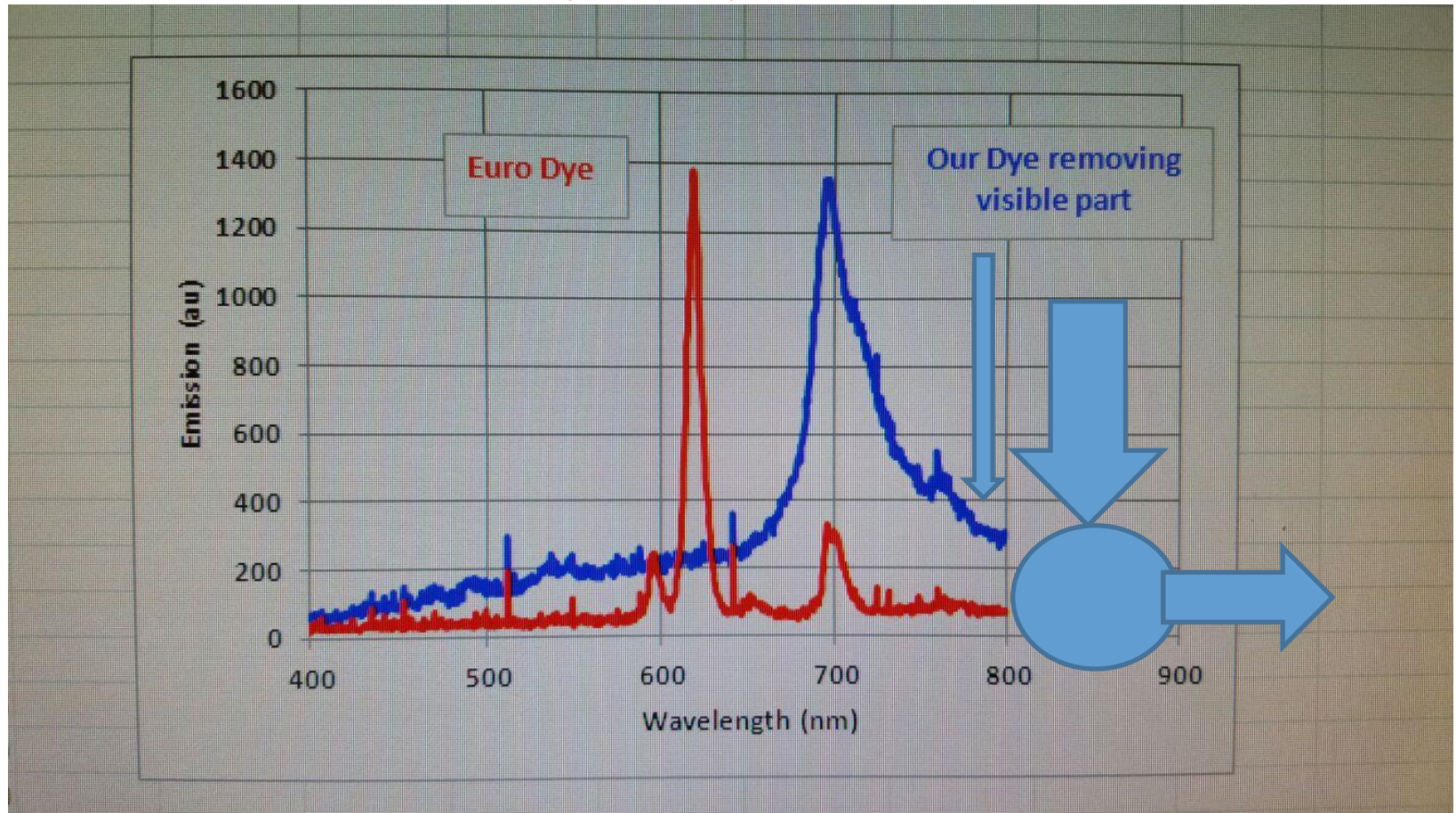
## On-going Research SACOS connected: Forensic Application (2)



First synthesized crystals

## On-going Research SACOS connected: Forensic Application (3)

Shifting the emission toward non visible spectrum  
Only seen by SACOS!



Second synthesized crystals,  
January 2016

Third generation synthesized  
crystals, February 2016



# On-going Research SACOS connected: Forensic Application (4)

Shifting the emission toward non visible spectrum  
Only seen by SACOS!

## High Temperature Furnaces with MoSi<sub>2</sub> heating elements

T max 1500 °C, 1600 °C, 1750 °C and 1800 °C

- Compact bench top furnaces with user-friendly parallel-guided door moving up-wards
- Double-walled housing with rear-ventilation to ensure low outcasing temperatures
- Insulation made of high grade aluminium oxide fibre with low thermal mass for very fast heating and cooling
- High grade heating elements made of Molybdenum-Disilicide (MoSi<sub>2</sub>) mounted in two sides
- Low power rating
- Heating elements controlled by thyristors for very precise temperature control, wear-free and noiseless
- High temperature uniformity inside the furnace chamber
- Exhaust pipe in the furnace ceiling

### Accessories:

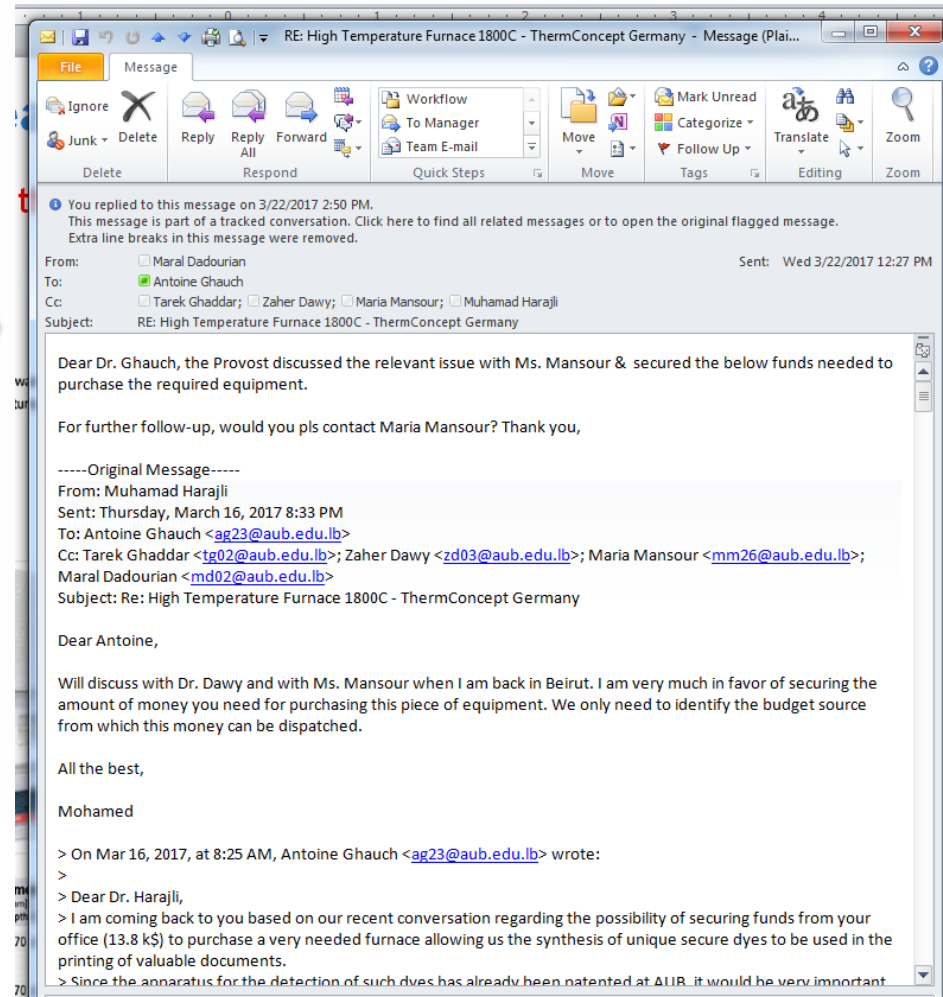
- Automatically driven exhaust flap in the ceiling
- Controlled cooling system to accelerate cooling times
- Protective gas connection, manual or automatic gassing system
- Semi-gastight housing with silicone sealing
- Control and documentation software
- Softstart switch



### Technical Data

Model	T max [°C]	Inner dimensions [mm] Width x Depth x Height	Volume [l]	Outer dimensions [mm] Width x Depth x Height	Power [kW]	Voltage [V]	Weight [kg]
HTL 01/15	1500	120 x 90 x 120	1	520 x 470 x 680	1,6	230 V 1/N	75
HTL 01/16	1600	120 x 90 x 120	1	520 x 470 x 680	1,6	230 V 1/N	75
HTL 02/16	1600	110 x 120 x 150	2	740 x 440 x 630	1,5	230 V 1/N	76
HTL 04/16	1600	150 x 150 x 150	4	740 x 440 x 630	3	230 V 1/N	83

Third generation synthesized  
crystals, February 2016



Fourth generation synthesized crystals to  
come soon end 2018

Dr. Antoine Ghauch | AUB | GCC

# On-going Research SACOS connected: Forensic Application (4)

## New PEER GRANT (2017-2020)

### A Research Grade Room Temperature Phosphorimeter

NI tools and electronic devices

3-4 months



Horiba spectrometer and  
Princeton Instruments for  
iCCD detector

3-4 months

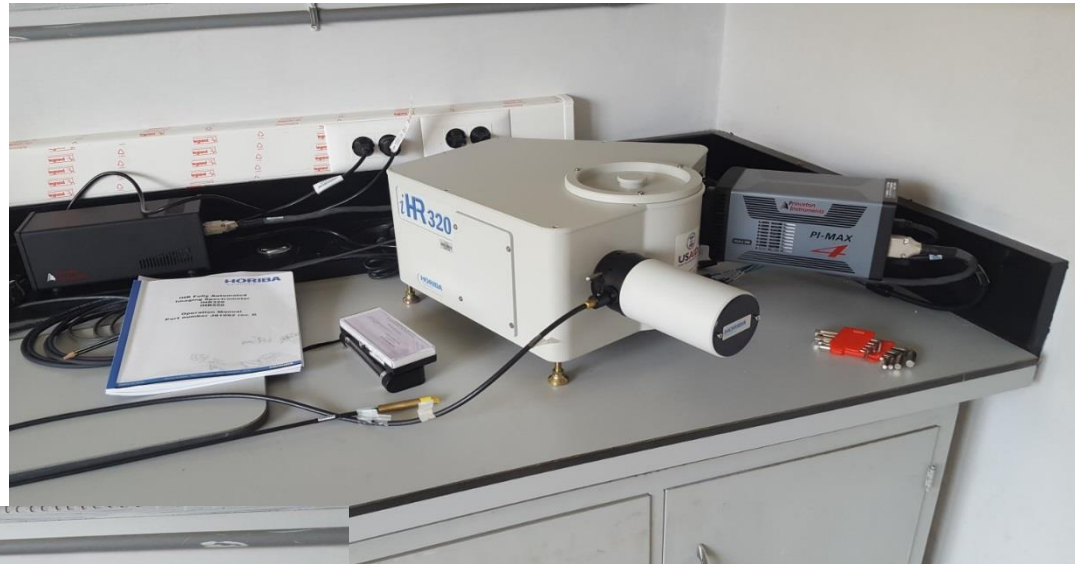
# On-going Research SACOS connected: Forensic Application (4)

## New PEER GRANT (2017-2020)

### A Research Grade Room Temperature Phosphorimeter

Testing and calibration Phase  
started last month

3-4 months



First measurements should  
be done on selected organic  
contaminants such as PAHs

3-4 months

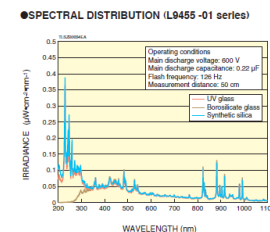


# On-going Research: Environmental application (1)

## New PEER GRANT (2017-2020)



1. Purchase a New iCCD Detector with an Electronic Shutter and an HPLC/DAD.
2. Miniaturization of Analytical Equipment for field measurement.
3. Improvement of SS-RTP by using bleached cotton and A4 banknotes papers as Solid Matrix.
4. Application of SS-RTP to new molecules based on the development of innovative Solid Matrices.



Made in the USA

### OEM Mini Grating Spectrometers Selection Guide

#### Miniature CCD & PDA Spectrometers • Single or Dual Fiber Optic Inputs

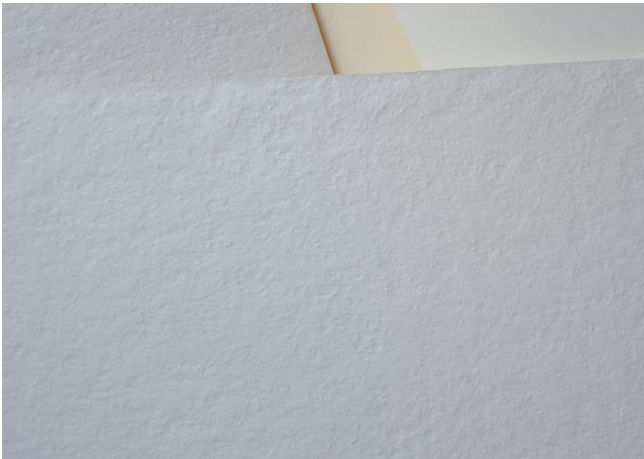
Miniature Spectrometers	Model	Minimum Readout Time	SNR (in Shot Noise conditions)	Coverage	Resolution & Pixel Format	Input Fibers
Compact/Low Cost	VS7000-CCD-HS VS7000-CCD-HD VS7000-PDA	1.3 msec 4.5 msec 3.5 msec	450:1 625:1 > 30,000:1	4 Gratings: 200-860nm 200-1050nm 380-750nm 350-1050nm	Sub 1nm to 5+ nm (grating dependent) 512/1024/2048 pixels	1-2 fibers
NEW / High End: UV-VIS-NIR	VS7000-CCD-HS1 (2D CCD) VS7000-CCD-HSE (Electronic Shutter)	1 msec (as linear CCD) 1 msec (4 μseconds)	500:1 525:1	4 Gratings: 200-860nm 200-1050nm 380-750nm 350-1050nm	Sub 1nm to 5+ nm (grating dependent) 2048 pixels	1-2 fibers
NEW / High End: UV	VS1110-CCD-HS1 (2D CCD) VS1110-CCD-HSE (Electronic Shutter)	1 msec (as linear CCD) 1 msec (4 μseconds)	500:1 525:1	1 Grating: 190-390nm	Sub 0.5nm to 5+ nm 1024 / 2048 pixels	1-2 fibers
NEW / High Throughput	CT300 CT330	1.6 msec	Up to 1100:1	2 Gratings: 200-800nm 200-890nm More with 2048 pixels	Sub 2nm to 5+ nm 1024 / 2048 pixels	Large Dia. Single Fiber

## New Solid Matrix to be tested / Additives? Nano



Bleached Cotton from a paper making industry.

Nanoparticles as Additives to enhance SS-RTP?



Cartoon made of the bleached Cotton.

Solid matrices to be placed in water serving as OCs concentrators for direct SS-RTP measurements.



Banknotes sheets (blank) made of the cartoon above (100% cotton).

# Acknowledgments



Partnerships for Enhanced  
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