Low-cost optical sensor for fast and accurate determination of liquid mixtures in foods or beverages

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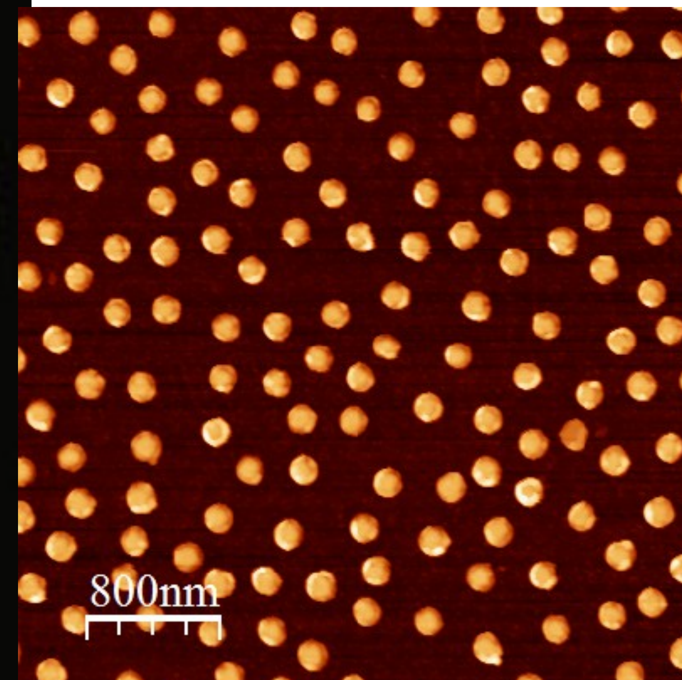
Sensor characteristics

- Low-cost (can be disposable)
- Optical (measures changes in refractive index)
- Fast (1 s)
- Accurate (1.56×10^{-5} refractive index units)
- Determination of **liquid mixtures** in foods or beverages: alcohol in water, mixtures of oil, any different liquids…Examples:
  - Is this oil pure or has something else on it?
  - What is the % of 2 liquids mixtured in a beverage?

Absoption of Light by nanoparticles (plasmons)

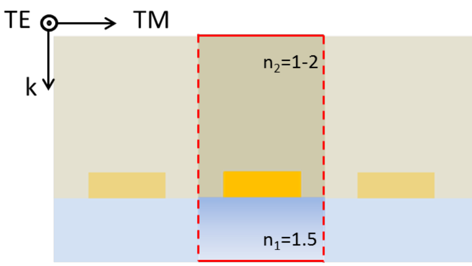
Luz transmitida



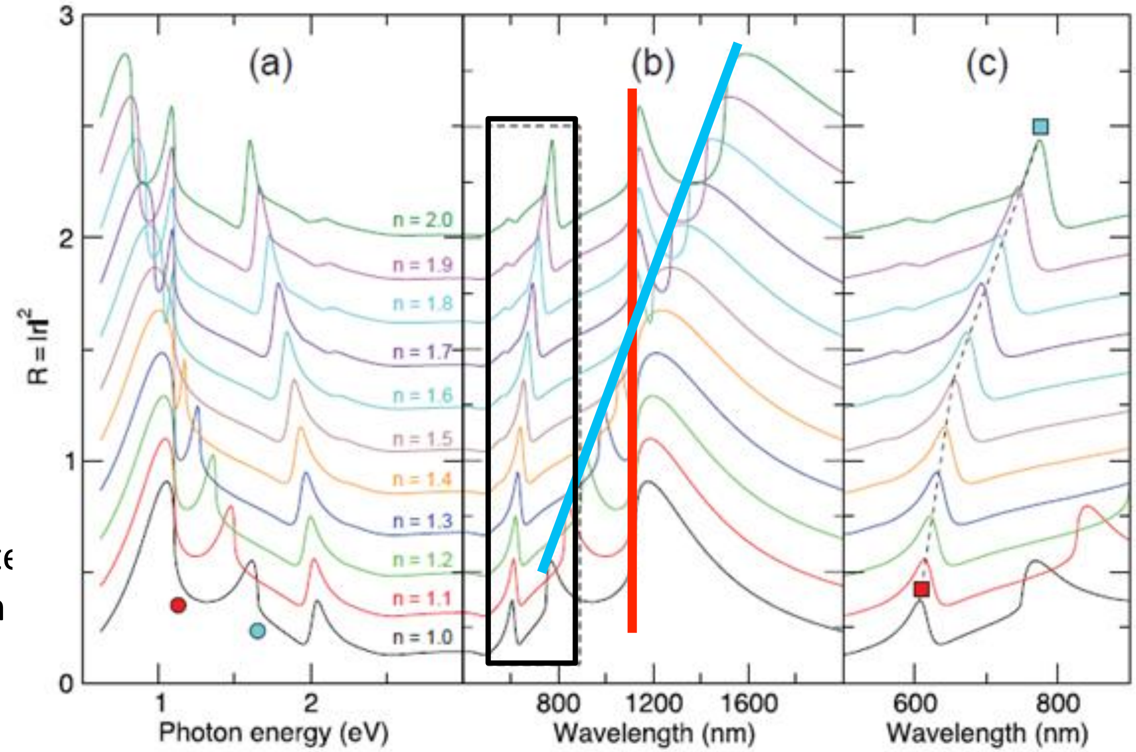
1) Metallic Nanostructures
2) A “good” metal (Au, Ag…)

Copa *Lycurgus* (Romano tardío, IV D.C)

Análisis de las propiedades ópticas de una **red de nanocintas de Au**.



Nanocintas de Au
375 nm de ancho
750 nm periodo



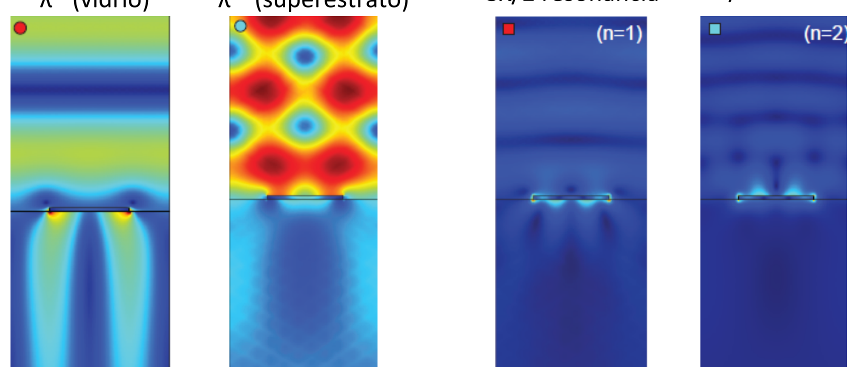
Anomalía de +:
Transición de un orden evanescente orden de difracción propagativo en red.

Condición de Bragg:

$$n_{in}2\pi/\lambda^{RA}\sin\theta_{in} + m2\pi/P = n_{out}2\pi/\lambda^{RA}\sin\theta_{out}$$

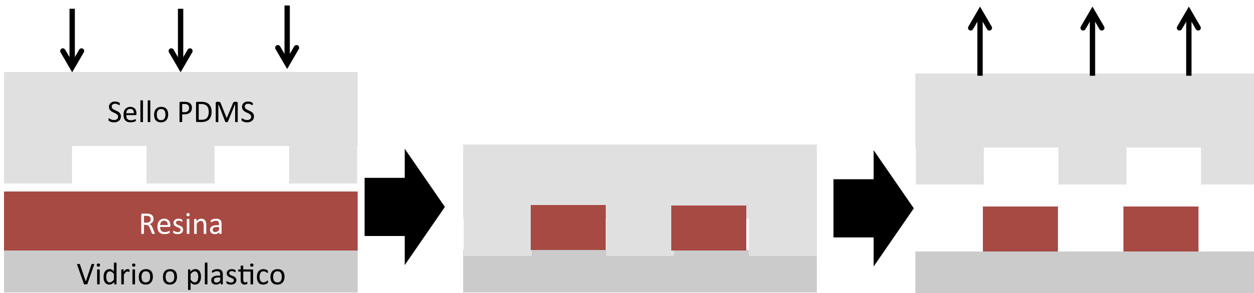
$$\lambda^{RA} = n_{out}P$$

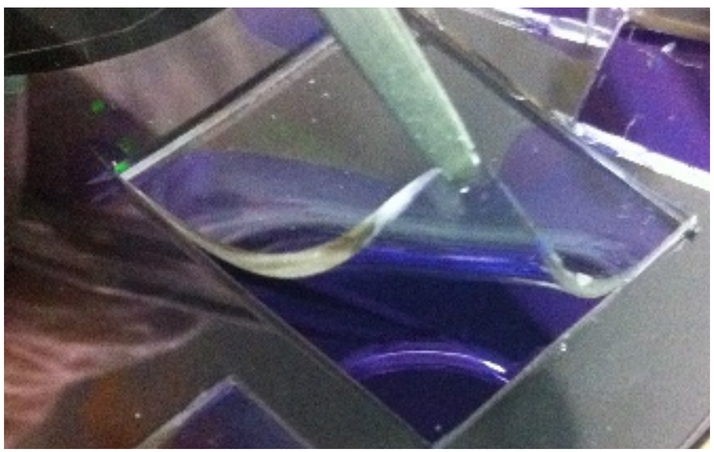
λ^{RA}(vidrio) | λ^{RA} (superestrato) | $3\lambda/2$ resonancia | $3\lambda/2$ resonancia

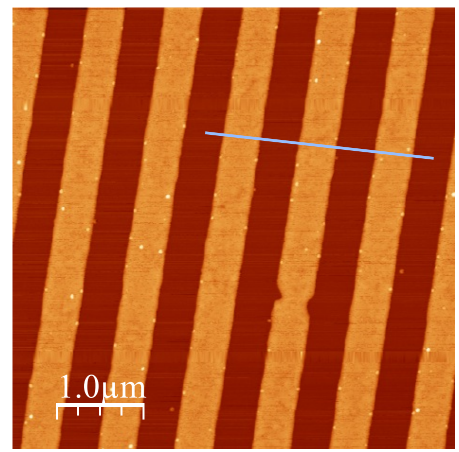


λ = 1119 nm | λ = 748 nm | λ = 606 nm | λ = 773 nm

Proceso de fabricación: litografia blanda

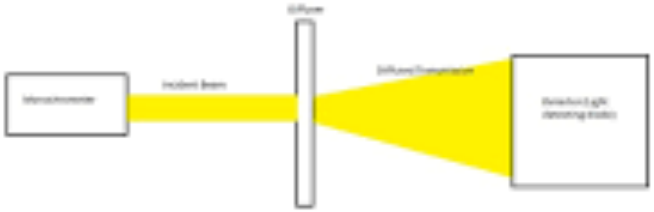


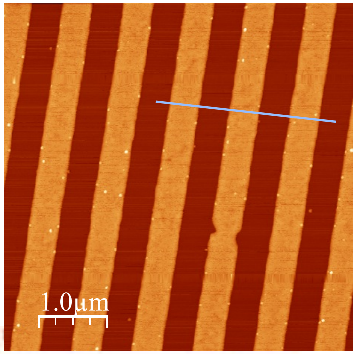


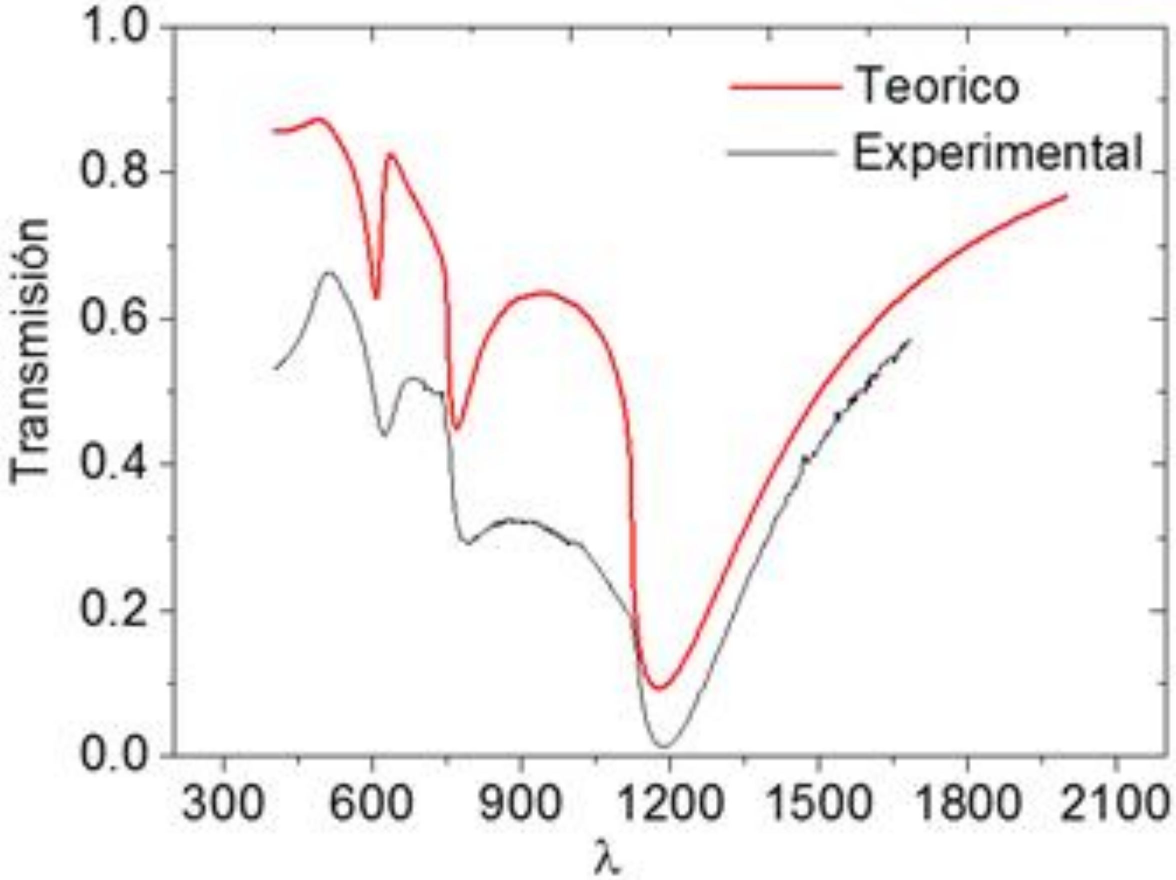


Sencillo, bajo coste, áreas grandes

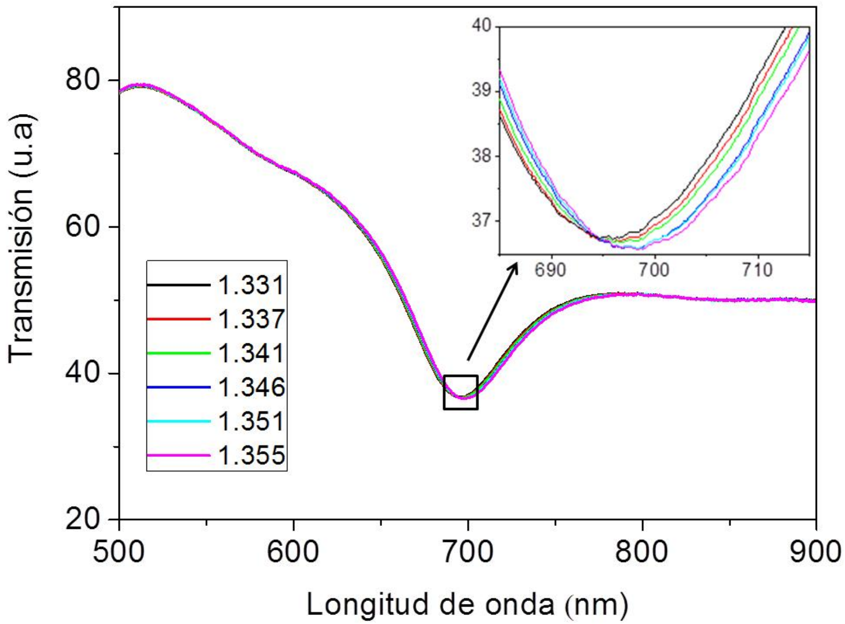
Resultados: medida transmisión incidencia normal





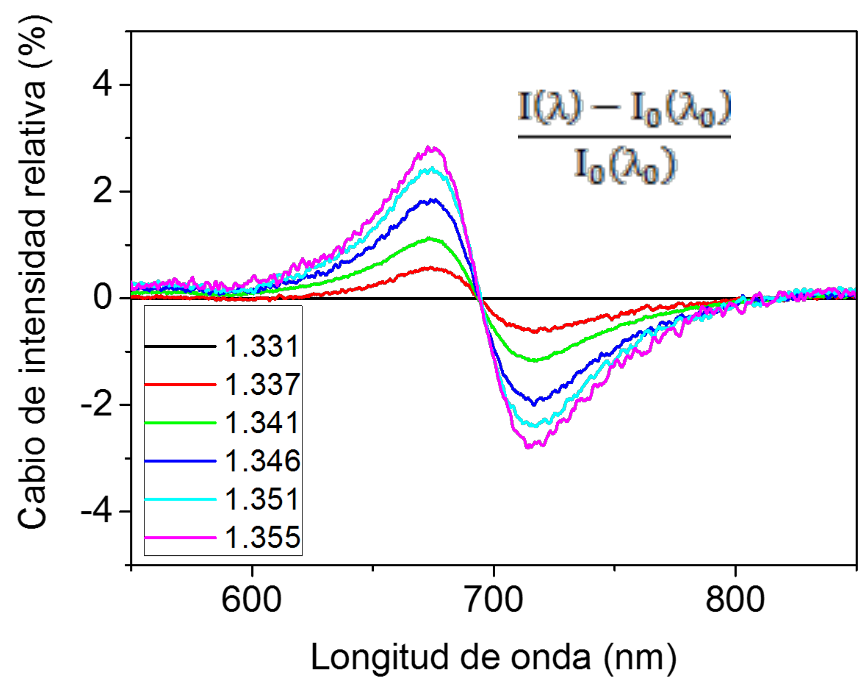


Resultados

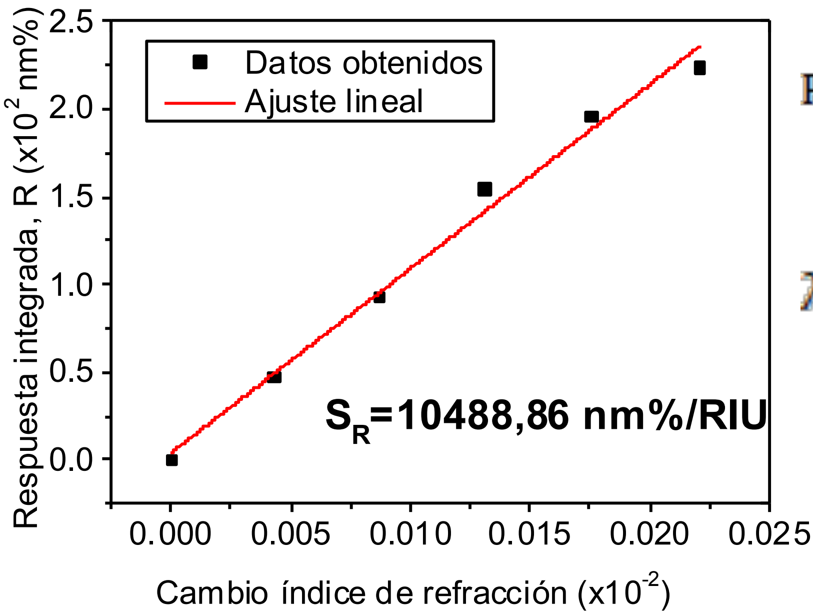


- Superestrato: Glicerol 0%, 3%, 6%, 9%, 12%, 15%)
- Lámpara halógena 100W
- Lente2x apertura 0.06
- Fibra óptica 1 mm de diámetro
- Espectrómetro portátil Ocean Optics USB4000

Variación de intensidad espectral respecto al agua.



Resultados



$$R = \sum_{\lambda_1}^{\lambda_2} \left(\frac{|I(\lambda) - I_0(\lambda_0)|}{I_0(\lambda_0)} \times \frac{(\lambda_2 - \lambda_1)}{N_\lambda} \right) \times 100\%$$

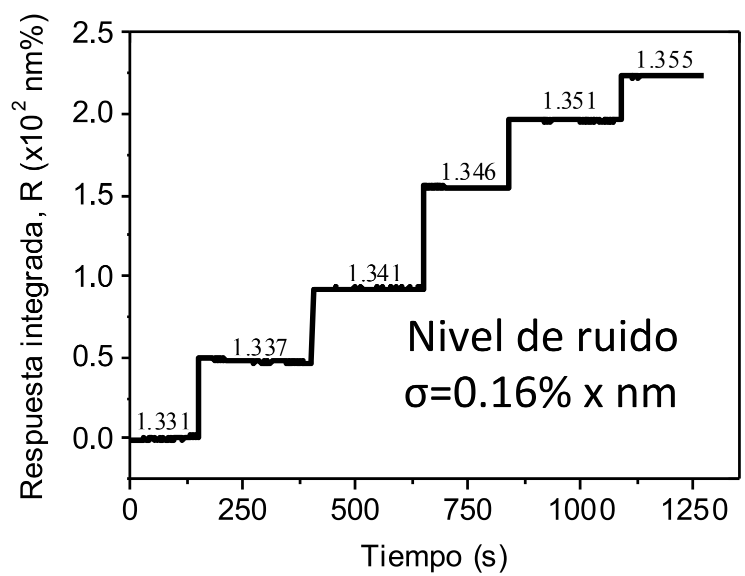
λ_1, λ_2 Intervalo de integración de intensidad relativa. 650 y 750 respectivamente.

N_λ Número de longitudes de onda dentro del intervalo de integración

Resolución de detección:

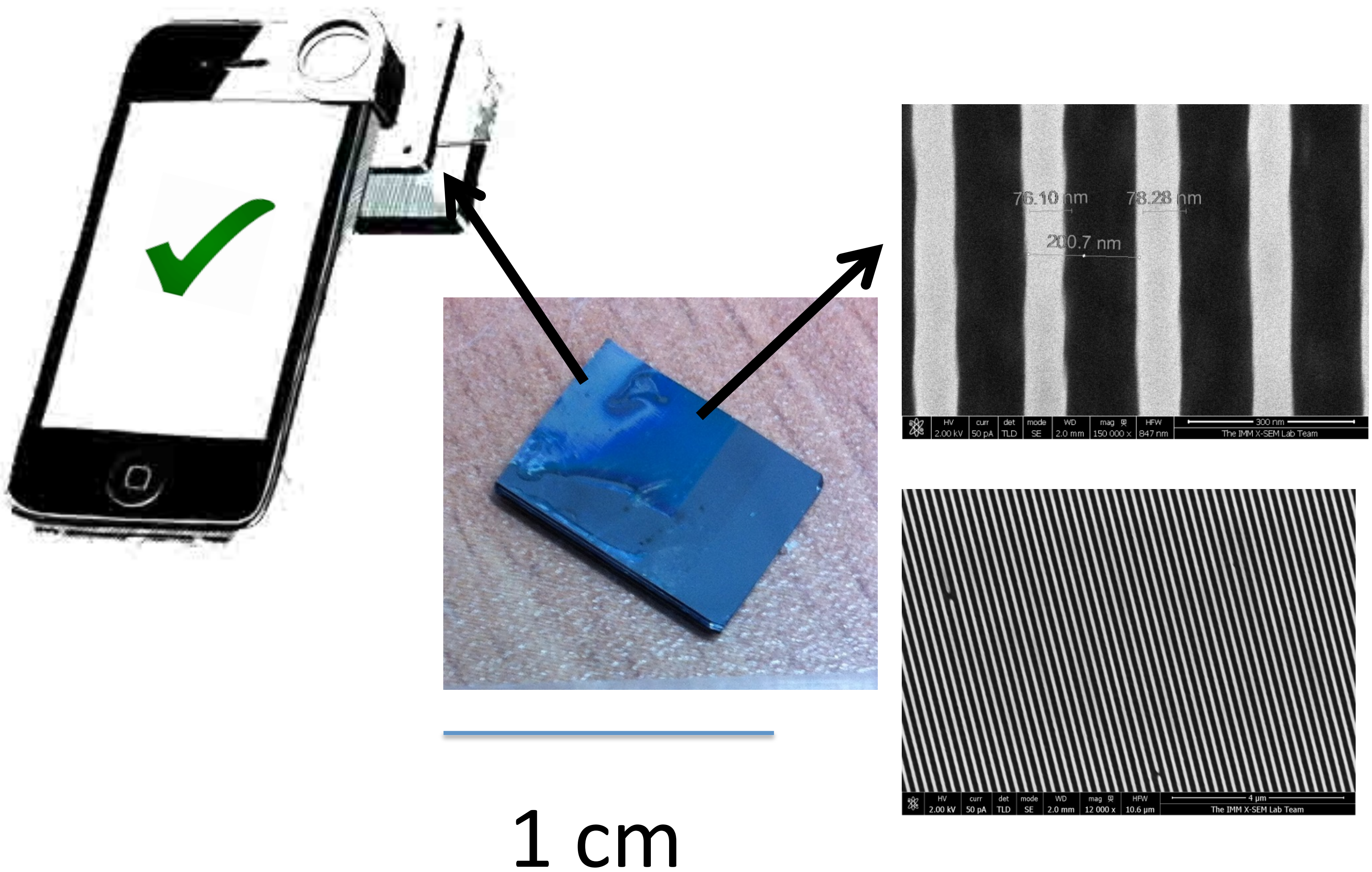
σ/S_R= **1.56 x 10^{-5}**

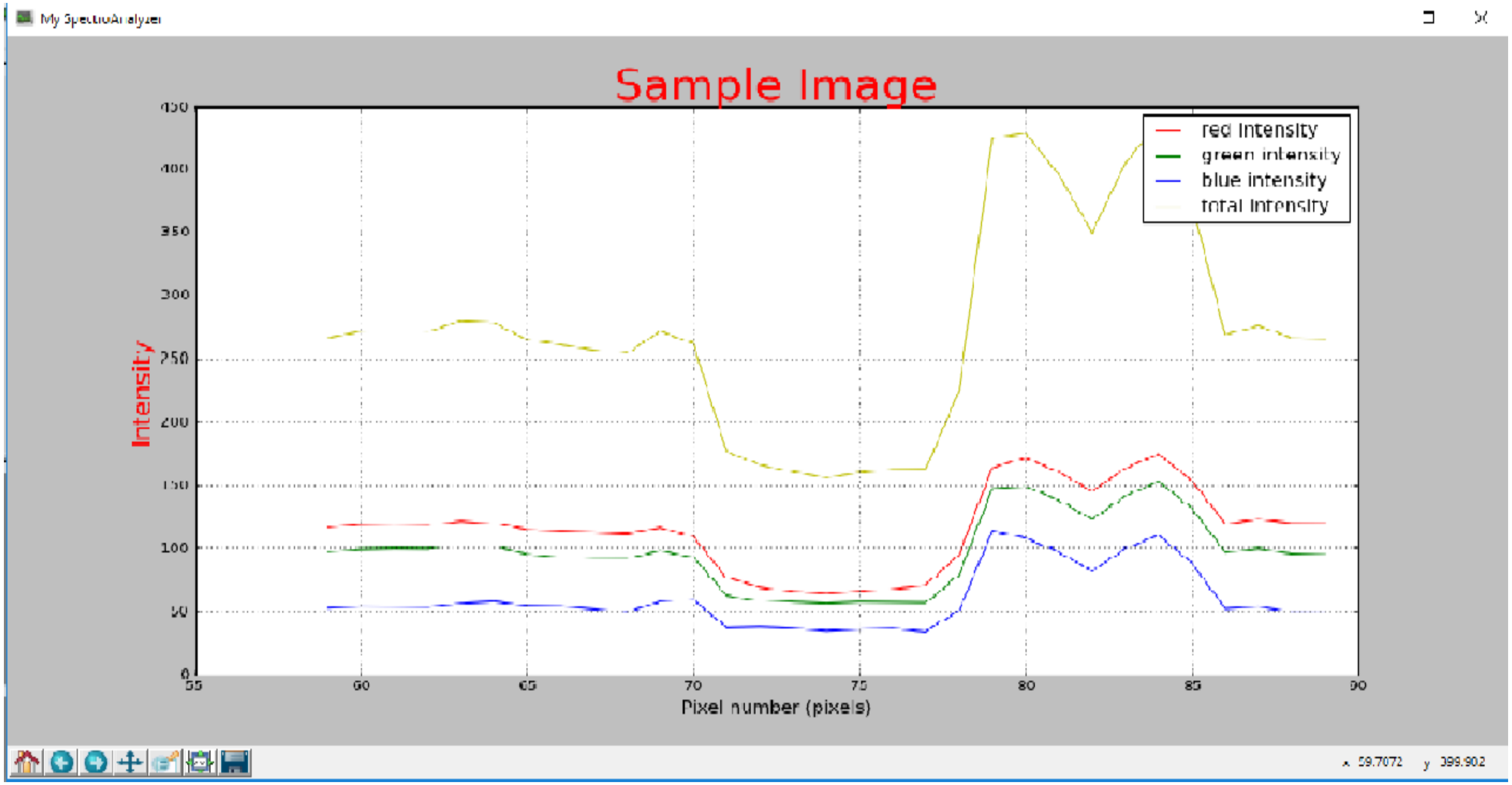
Área activa 0.75 mm de diámetro
N=200 τ=5ms -> **Resolución temporal 1s**

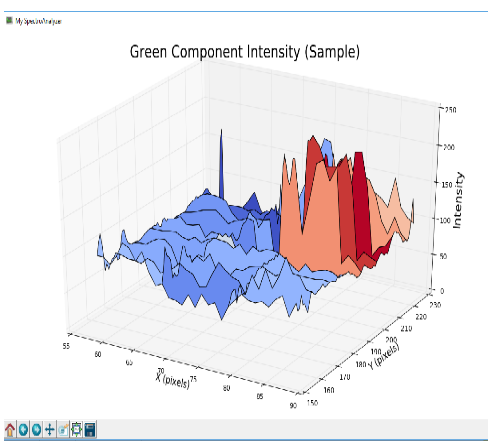


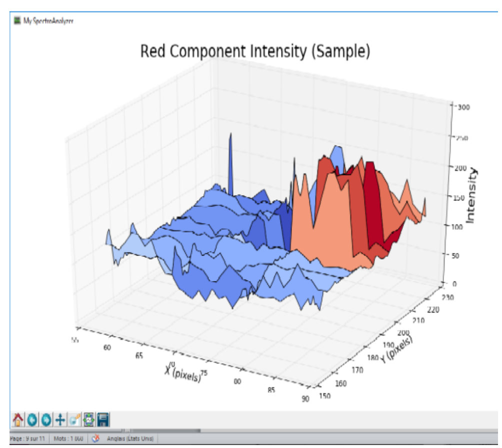
Performance of the sensor

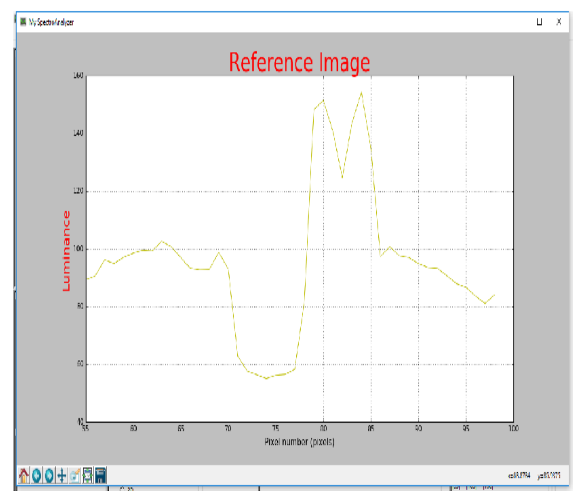
- Very small volume for detection, 0.0025 mL
- Spot of detection d=0.75 mm
- In this small volume, **it can detect a mass as small as 0,1 mg**
- **Or a volume as small as $8x10^{-5}$ mL**.
- The detection can be as fast as **1 second**.
- **It can be used with a smartphone if an specific but simple device is attached and specific software is used**


76.10 nm
78.28 nm
200.7 nm
HV 2.00 kV | curr 50 pA | det TLD | mode SE | WD 2.0 mm | mag 150 000 x | HFW 847 nm
300 nm
The IMM X-SEM Lab Team
HV 2.00 kV | curr 50 pA | det TLD | mode SE | WD 2.0 mm | mag 12 000 x | HFW 10.6 μm
4 μm
The IMM X-SEM Lab Team
1 cm


Sample Image
red intensity
green intensity
blue intensity
total intensity
Intensity
Pixel number (pixels)
0
50
100
150
200
250
300
350
400
450
55
60
65
70
75
80
85
90


Green Component Intensity (Sample)
X (pixels)
Y (pixels)
Intensity


Red Component Intensity (Sample)
X (pixels)
Y (pixels)
Intensity


Reference Image
Luminance
Pixel number (pixels)

Conclusions

- We present a new way of easy, optical detection using a nanophotonic sensor.
- Applications can be from detection of the *quality of food* (virgin or mixed olive oil, wine or beers…) quality of pure or mixed alcohols, gasoline, etc. to identification of specific labeling and security.
- The nanophotonic sensor only needs a very small volume for detection of 0.0025 mL and can detect a mass as small as 0,1 mg or a volume as small as $8x10^{-5}$ mL. The detection can be as fast as 1 second.
- The sensor can be coupled to a smartphone for an easy detection of the properties of the substance.
- It can be used in an easy way with a smartphone with home-made MYSA App

E. Baquedano, M. U. González, R. Paniagua-Domínguez, J. A. Sánchez-Gil, and P. A. Postigo, "Low-cost and large-size nanoplasmonic sensor based on Fano resonances with fast response and high sensitivity," Opt. Express 25, 15967-15976 (2017)