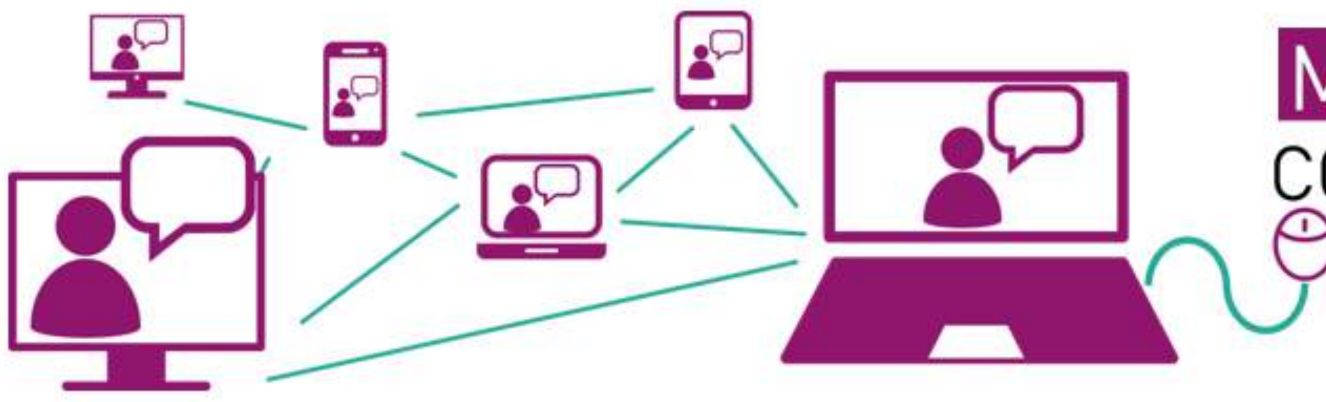

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BIOSENSORS FOR PANDEMICS

OPTOFLUIDIC FIBER PLATFORM FOR MOLECULE SENSING

CHRISTIANO J. S. DE MATOS[1], PILAR. G. VIANNA[1], RODRIGO M. GEROSA[1], DANIEL GRASSESCHI[2], SERGIO H. DOMINGUES[1]

1 – MackGraphe, Mackenzie Presbyterian University, R. da Consolação 896, São Paulo, Brazil
2 – Surface Chemistry & Nanomaterials Laboratory, Chemistry Institute, UFRJ, Rio de Janeiro, Brazil

Introduction

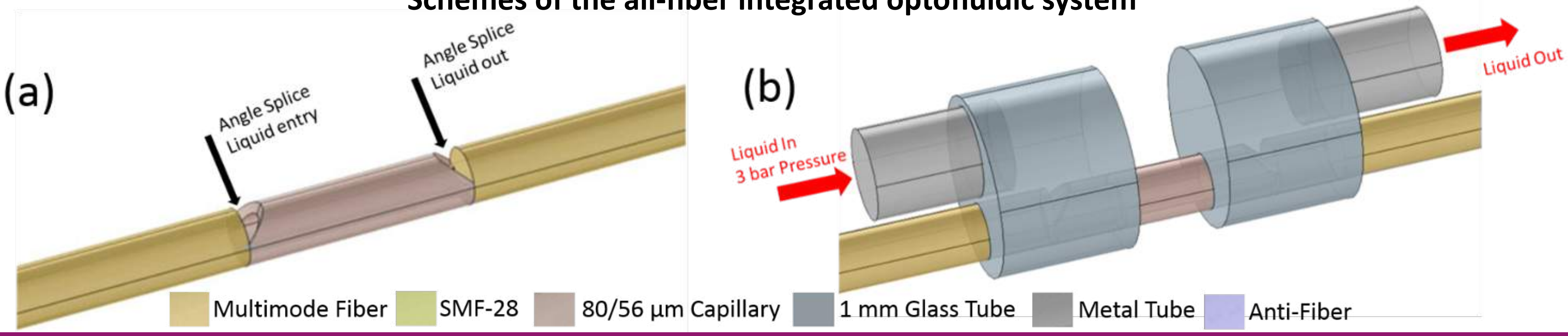
- Optical sensors have been successful in several areas. In biosensing, they can present robustness, high sensitivity and provide chemical composition information.
- Optofluidic sensors have been demonstrated that combine the compactness and low sample volume of microfluidics with the advantages of optical sensing.
- Most optofluidic systems are based on integrated optics on chips. Fiber optofluidics, however, is also available, offering full compatibility with optical fiber technology

Here:
- Some of the work developed in fiber optofluidics at MackGraphe is reviewed, including a stable, highly sensitive and low-volume-requirement in-fiber surface enhanced Raman spectroscopy (**SERS**) system, based on a graphene-oxide (**GO**)/gold nanorod (**AuNR**) nanocomposite.
- Application to the detection of viruses is discussed.

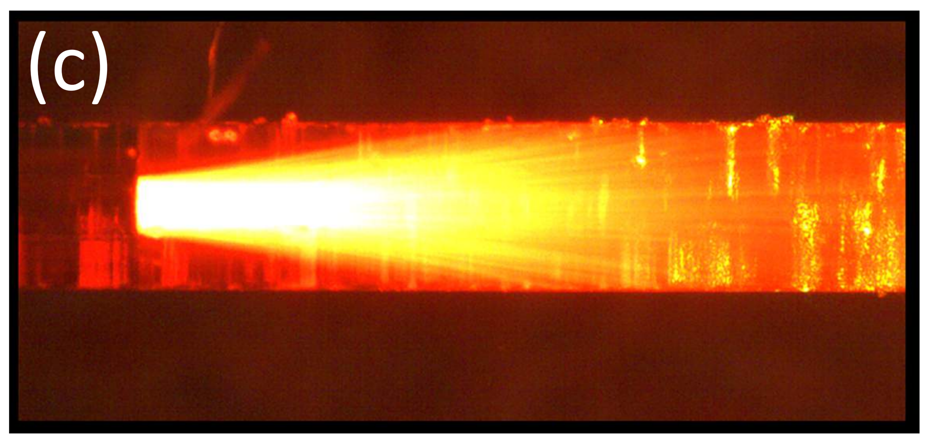
All-fiber integrated optofluidics

- We have demonstrated several optofluidic fibers throughout the years, including the system below, in which standard optical fibers were spliced to a capillary fiber (80 or 56 µm inner diameter), with lateral inlets to allow fluids to flow along the capillary (a).
- A pressurized fluidic system (b) allowed the flow of liquids, with only ~50 nanoliters required to fill the capillary fiber and 1-2 ml required to operate an all-fiber dye laser (c) for 5 minutes [1].

Schemes of the all-fiber integrated optofluidic system



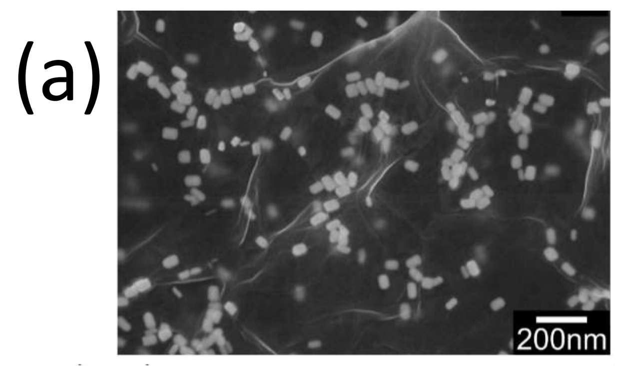
Dye luminescence in the optofluidic laser setup



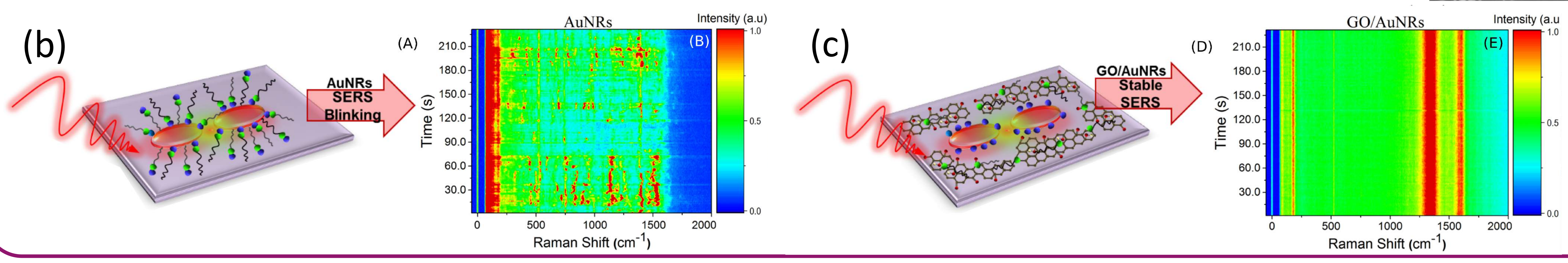
GO/AuNR substrate for stable SERS

- In parallel, we have demonstrated that a GO/AuNR nanocomposite, (a), yielded extremely sensitive and stable SERS signals [2].
- While AuNRs provided an up to 10^{10} Raman signal enhancement (for Rhodamine 640), GO immobilized the AuNRs and removed the long tail of CTAB molecules (used during synthesis) from their surface, enabling a cleaner and up to ~5× more stable SERS signal, (b) and (c).

Nanocomposite (SEM image)



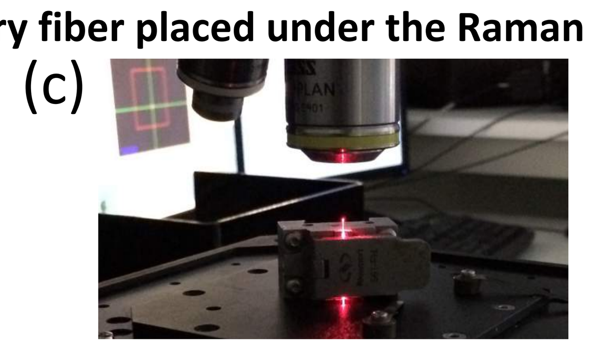
Schematic representation and SERS signal time series for AuNR (a) and GO/AuNR (b) substrates



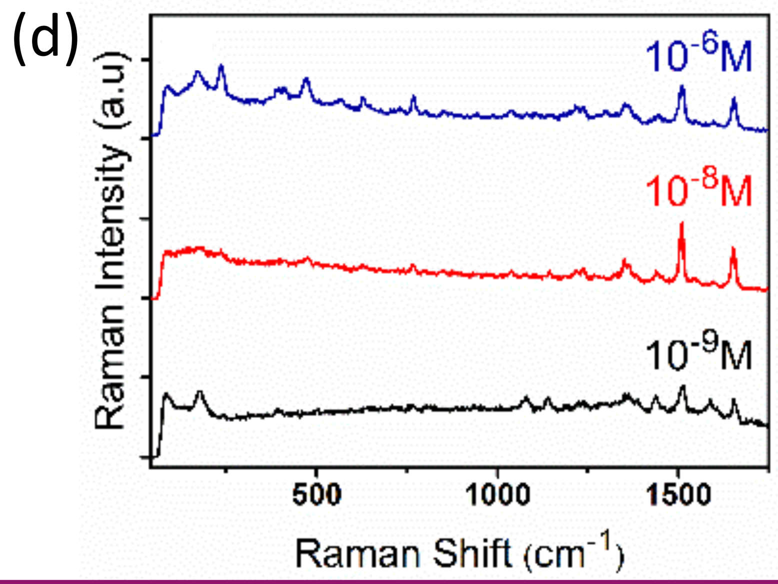
In-fiber optofluidic SERS

- An in-fiber optofluidic SERS sensor was then developed. Capillary fibers were coated with GO using a developed [3] quick dry method (a).
- Then, an AuNR suspension filled the same fiber, and the nanorods electrostatically attached to GO (b). The composite was stable and the fiber could be washed with no detectable changes.
- SERS of rhodamine solutions was carried out in a Raman confocal microscope (c). Rhodamine 640 solutions down to 10^{-9} M were detected in <1 sec (d), requiring 150 nanoliters (75 femtograms of rhodamine) [4].

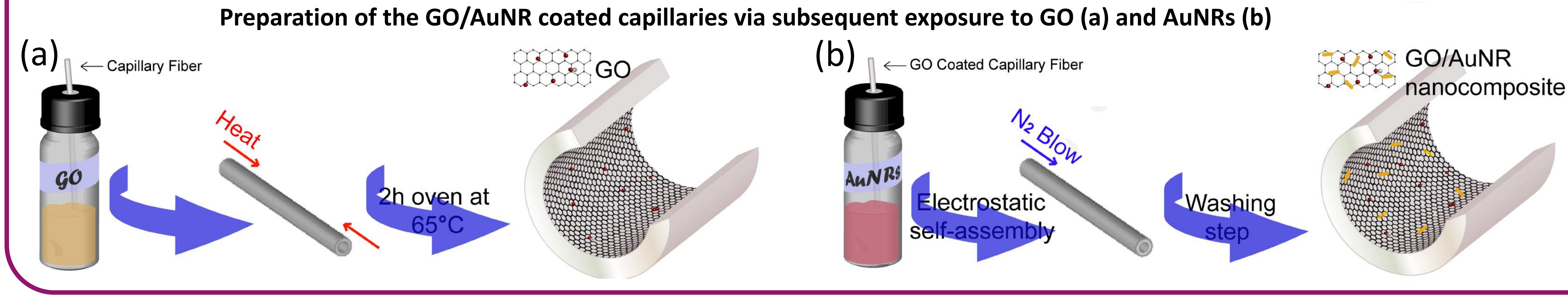
Capillary fiber placed under the Raman microscope



SERS spectra of various Rhodamine 640 solutions



Preparation of the GO/AuNR coated capillaries via subsequent exposure to GO (a) and AuNRs (b)



Conclusions and outlook

- We demonstrated both an all-fiber optofluidic system and an in-fiber SERS sensor. The 2 systems can be combined to yield practical and compact biosensors.
- By functionalizing GO with the relevant biomarkers, the sensor may yield sensitive viral sensors with ultralow sample volumes.
- The optofluidic fibers can also be used in combination with other optical transduction methods (e.g., luminescence, absorption).

CONTACT PERSON

Christiano J. S. de Matos
MackGraphe, Brazil

cjsdematos@mackenzie.br
www.mackenzie.br/mackgraphe/

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