Fabrication of 3-D, Wavelength-Tuneable, Photonic Crystals for Space-based, mm-Wave, Terahertz, and Infrared Communications

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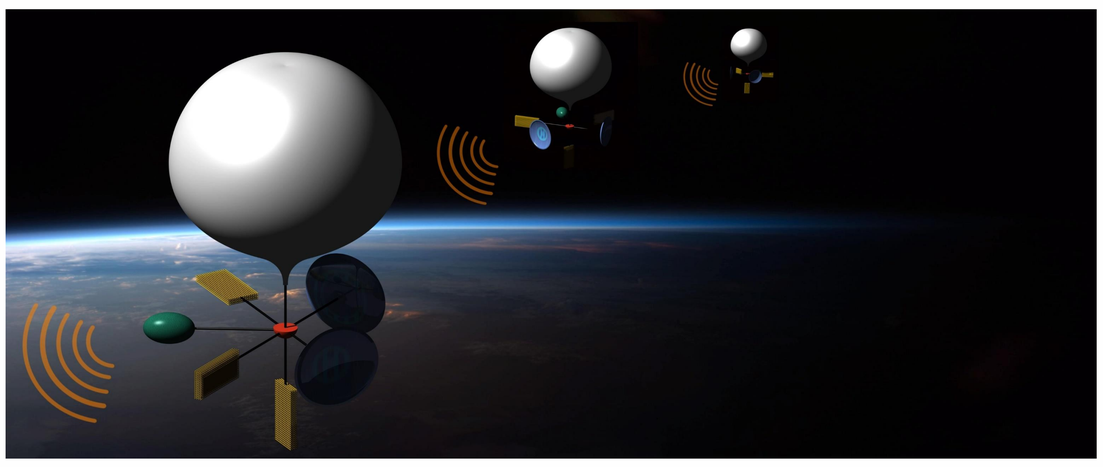
Introduction

At the intersection of electronics and photonics, this collaborative research initiative with SmartSat CRC and La Trobe University emerges to advance tunable **Photonic Crystals** with the aim of enhancing **satellite-to-satellite** communication systems, **high-altitude balloon-to-balloon** or **satellite-to-high-altitude-balloon** connections.

Photonic crystals, periodic structures, enable intricate control of electromagnetic waves beyond traditional refraction or reflection. Our research centres on 3-D photonic crystals, offering superior band gaps and tunability. These crystals promise innovation in **advanced communication, sensing, and image filtering devices.** We are creating woodpile structures that act as 3D tunable Photonic Crystals**.**



Aims

Develop novel tunable photonic crystals at high pressures using HP-LCVD:

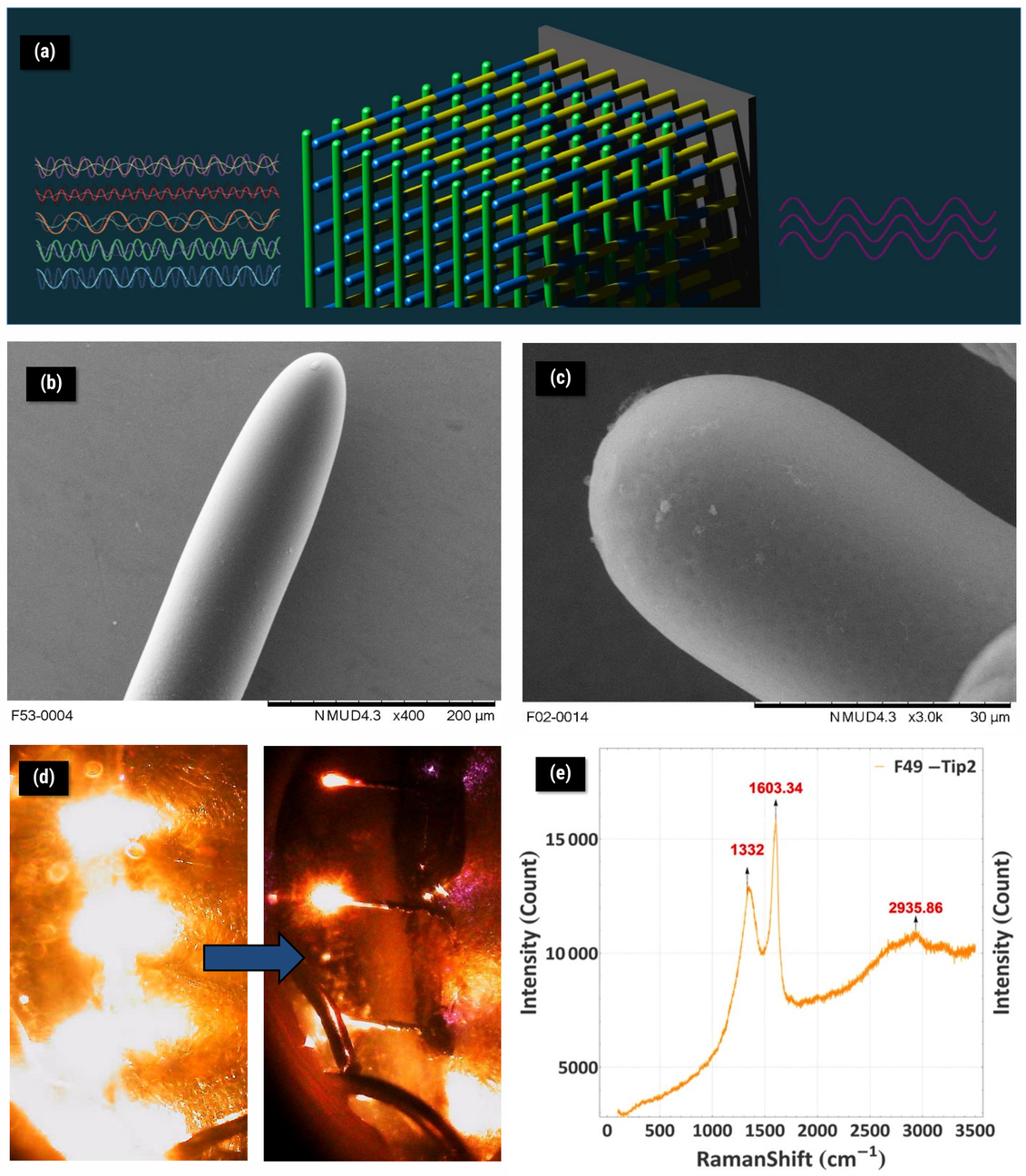
- Growth of **Carbon**, **Titania** and **Carbon-Titania** fibres via HP-LCVD.
- Parallel growth of precision tapered and graded fibres.
- Creation of woodpile structure, graded materials, etc. for tunable Terahertz filters.

Methods

We’re developing a novel fabrication technique, **Hyperbaric Pressure Laser Chemical Vapor Deposition (HP-LCVD)**, to grow 3-D microstructures. This method is perfect for crafting high precision metamaterials and photonic crystals. HP-LCVD employs a focused **laser beam** within a **hyperbaric chamber** to decompose precursor gases, allowing precise customization of 3-D microstructures through pressure, composition, and flow rate adjustments, creating versatile multi-material arrays.

Results to date

We have successfully grown 165+ carbon and titania fibres and fibres arrays on **graphite, stainless-steel** and **Balsa wood** substrates, employing a variable laser power within the range of **14 mW to 3W** and operating at pressures ranging from **1 to 27 bar.** Our ongoing work involves the simultaneous parallel growth of high dielectric constant fibres.



(a) Terahertz photonic crystal woodpile structure, (b) & (c) SEM image of carbon fibre grown at 1.3W and 1.5W, (d) Parallel growth of multiple carbon fibres array simultaneously, (e) Raman spectra of carbon fibre showing the growth of a sp3 form of carbon, (f) Growth of Titania fibre, (g) Growth of an array of Titania fibres at 80mW.

References

- Lipson, R. H., and C. Lu. "Photonic crystals: a unique partnership between light and matter." European Journal of Physics 30.4 (2009): S33.
- Maxwell, J. L., et al. "High Temperature Nanocomposites For Nuclear Thermal Propulsion and In-Space Fabrication by Hyperbaric Pressure Laser Chemical Vapor Deposition." Journal of the British Interplanetary Society 66 (2013): 328-333.

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