

Laser-Heated Pedestal Growth and Raman DTS for Harsh-Environment Applications

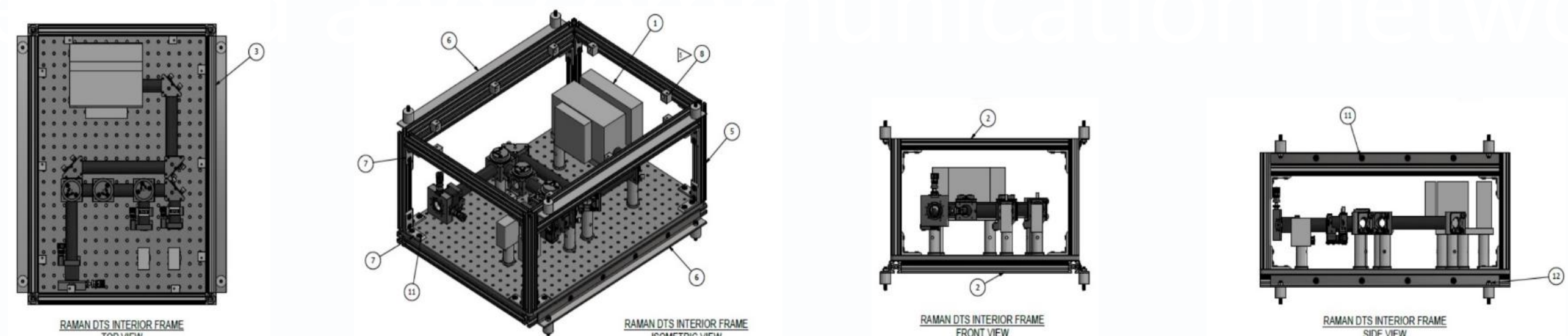
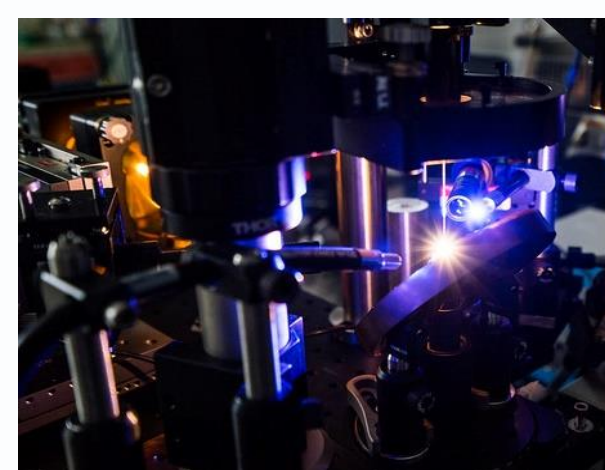
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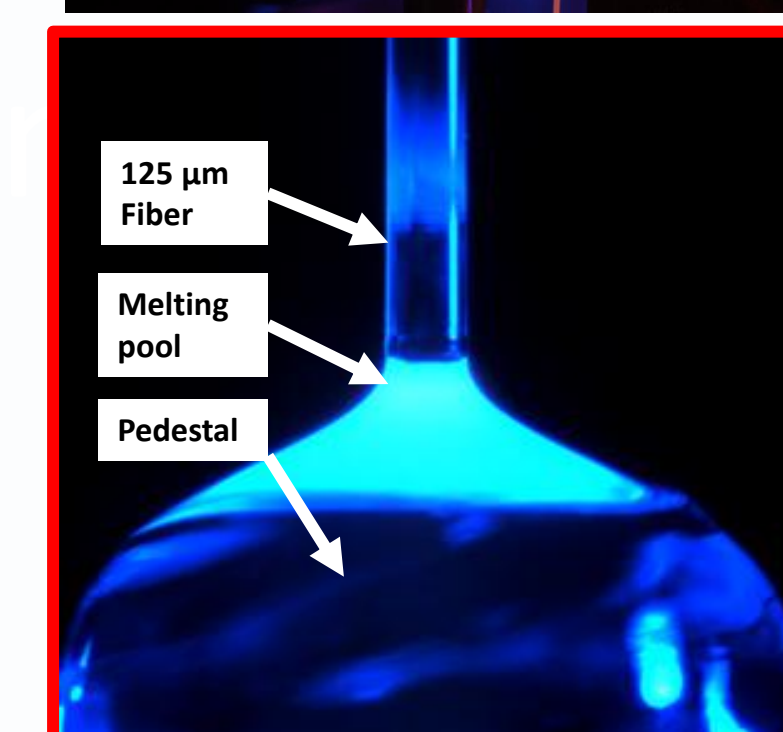
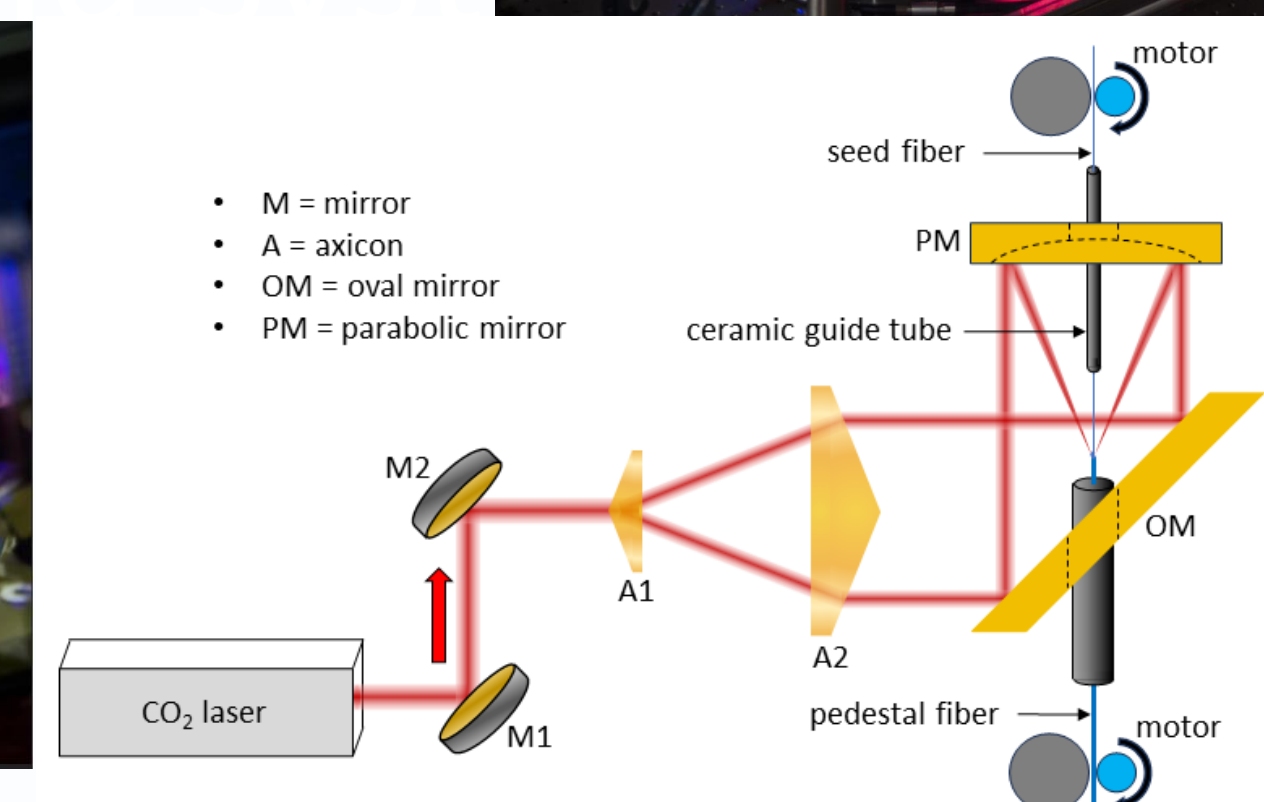
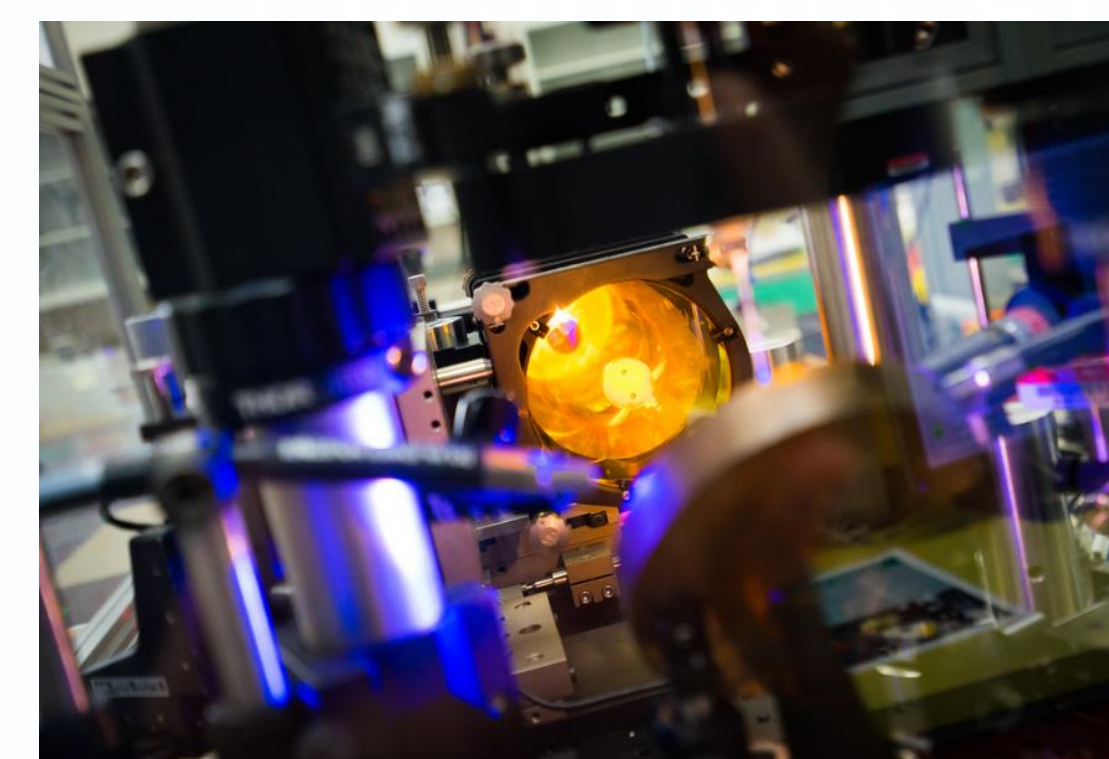
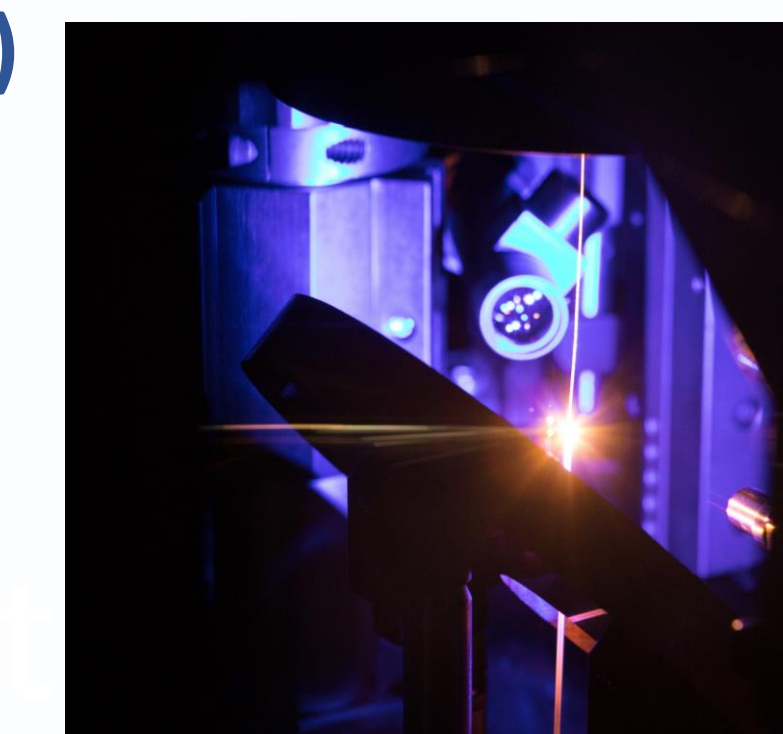
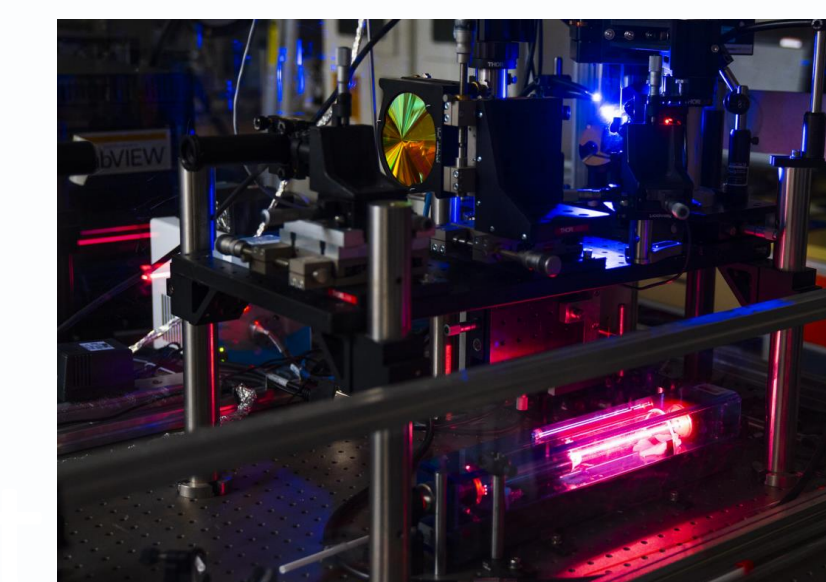
Technology Summary

- New single-crystal fibers withstand harsh conditions
- Distributed optical interrogation enables precise core and coolant control
- Allows measurement of loop temperatures, piping strain, or other important parameters
- Reactor automation accelerates Molten Salt Reactor designs, ushers in a new paradigm of distributed core-monitoring
- Sensor fibers produce thousands of data points to aid reactor designers or improve reactor operational awareness



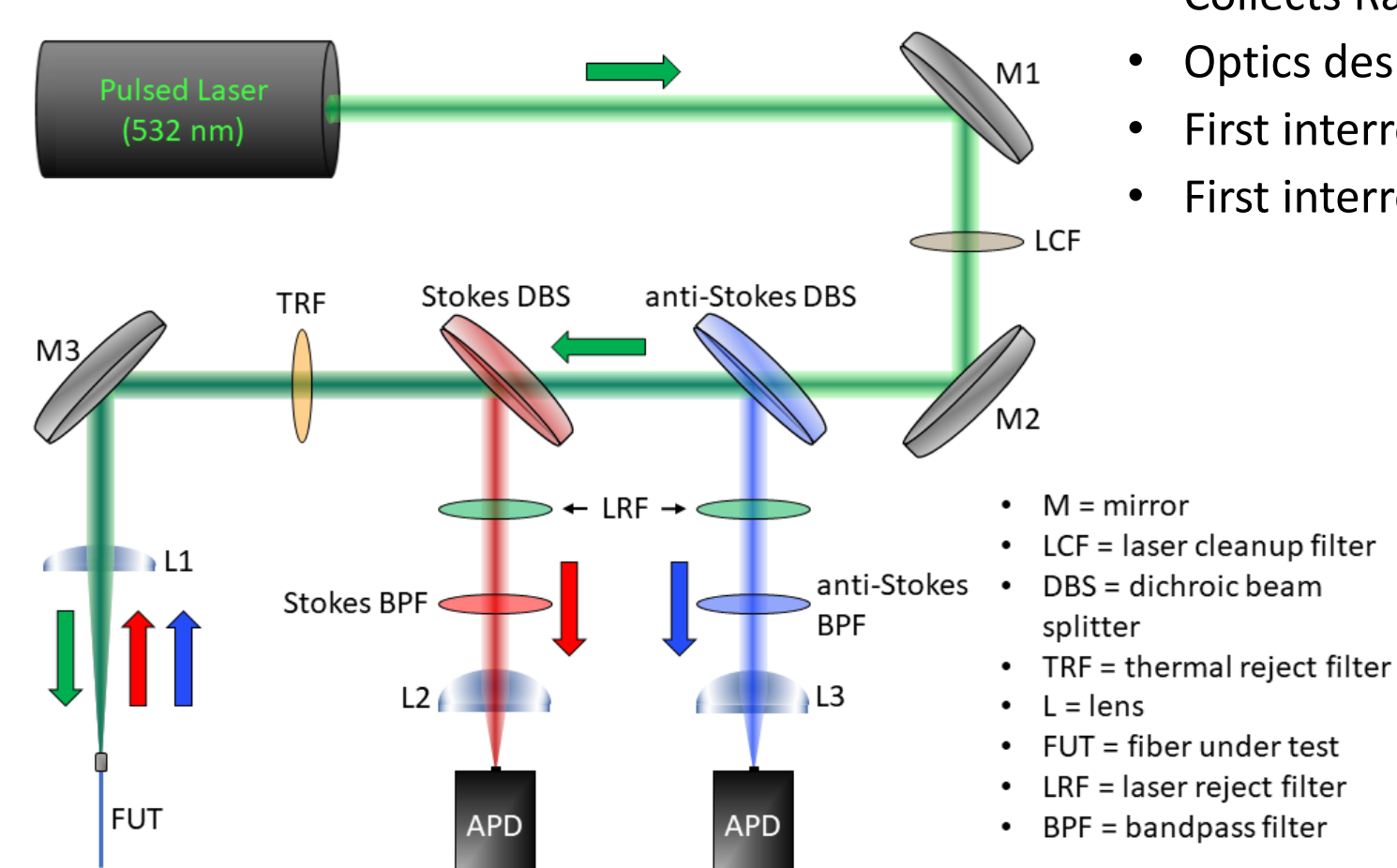
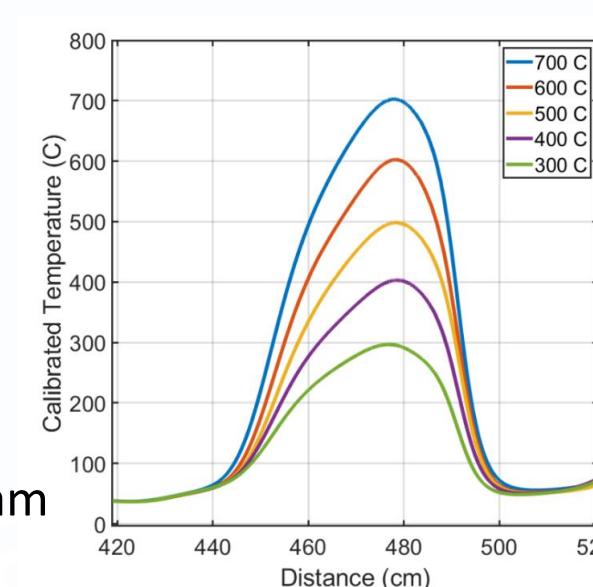
Laser-Heated Pedestal Growth (LHPG)

- CO₂ laser source for heating
- “Doughnut” beam shaper surrounds molten zone with light
- Motors advance feedstock (pedestal) and fiber
- Slow process (mm/min)
- Grows pure crystals (no cladding)



Integrated Raman DTS System and SOFC Tests

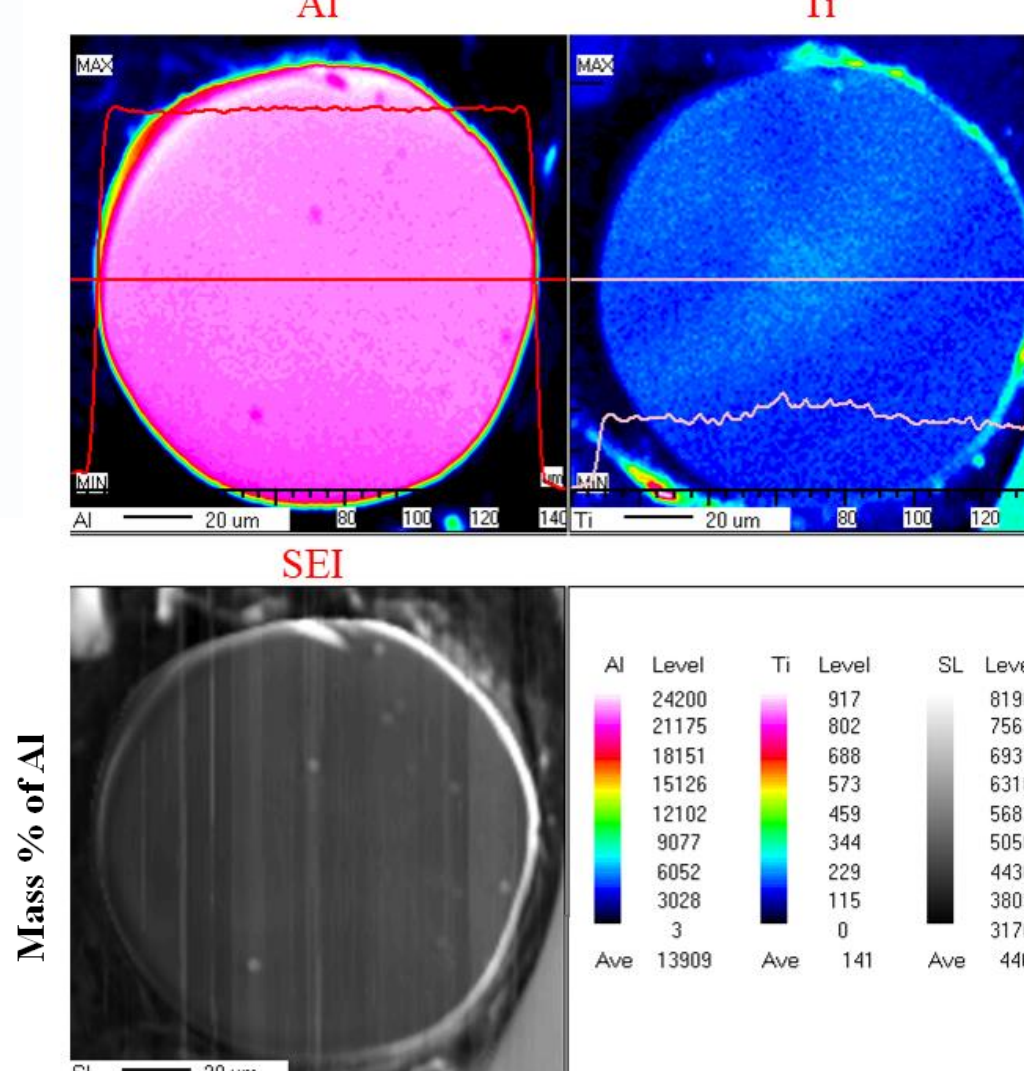
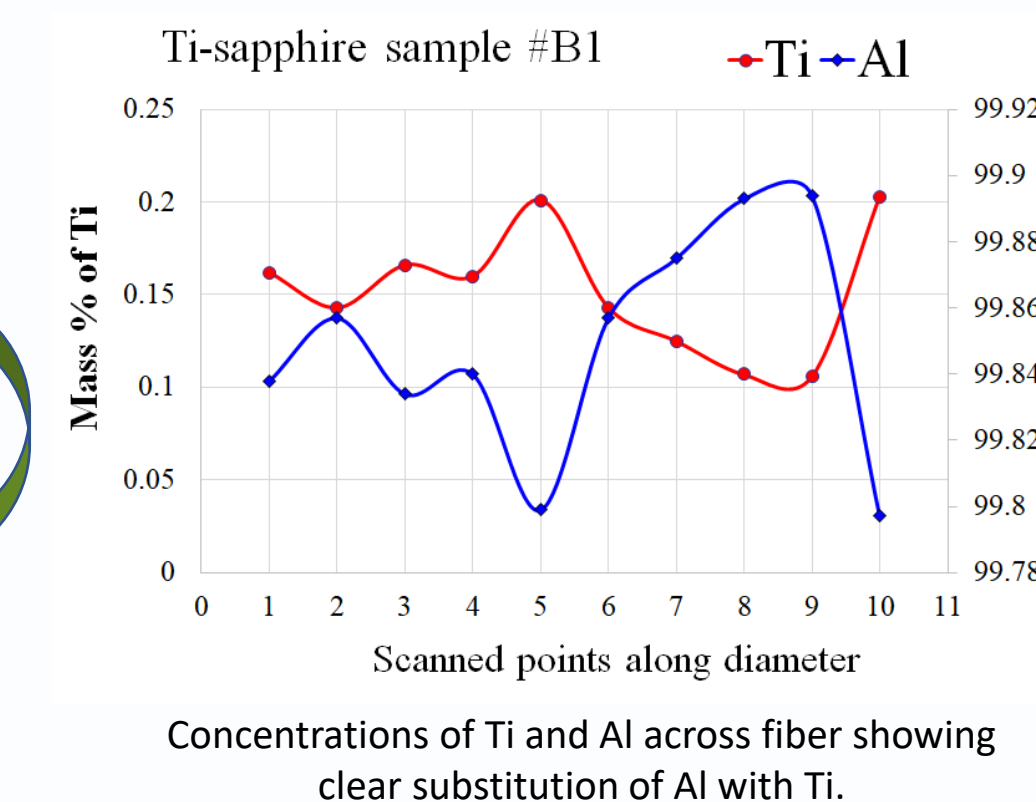
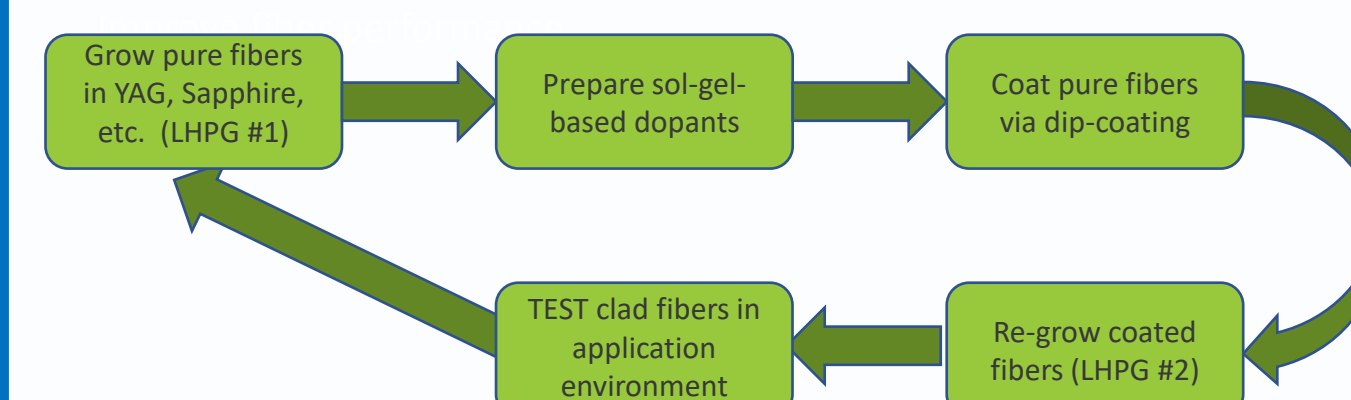
- Introducing the NETL Raman distributed temperature sensor (DTS)
- Pulsed ~350 ps, 532 nm green laser
- Excites Raman scattering as pulse propagates
- Collects Raman with fast avalanche photodiodes
- Optics designed for sapphire or yttrium aluminum garnet (YAG) fiber
- First interrogator for single-crystal-fiber
- First interrogator produced by NETL's Interrogator Development Program



Test of fiber-based H₂ sensor in a solid oxide fuel cell (SOFC). Bottom Left: Inside of SOFC in which the fiber sensor is inserted; Bottom Right: Raman DTS system and SOFC; Top Right: Temperature curves measured via the Raman DTS.

Dopant Additions via Regrowth of Sol-gel Coated Fiber

- Grow cladded fibers with two-stage LHPG
 - Sapphire or yttrium aluminum garnet (YAG)
 - Sol-gel (or other) dopant additions, such as Ti, Cr, and Ce
- Evaluate materials' compatibility in energy systems
- Improve fiber performance



Automatic Dopant Segregation through LHPG. Top left: Electron probe microanalysis map of Al concentration in sapphire fiber; Top right: EPMA map of Ti concentration; Bottom left: Scanning electron image of fiber.