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Optical fiber based sensors for targeted salt detection and monitoring

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Motivation

Aquifers are the major source of freshwater in urban areas as well as for agricultural irrigation. An increase in population and human activities has increased the demands on aquifers. In the coastal areas, excessive pumping from near coastal discharge/pumping wells may cause saltwater intrusion in the nearby aquifers. This is much more than a localized problem because sustainability of resources are at the base of socio-economic development. Hence the saltwater intrusion in aquifers needs to be monitored.

The existing methods of detection involves electrochemical methods that could involve introducing electrical wires, electrodes and/or potentially harmful materials into the aquifer, which would severely complicate the installation, robustness and safety of the sensor. A promising solution is to use Fiber Bragg Gratings (FBGs) (fig.1) as an electrodeless sensing tool which is harmless to the environment and can be used for low loss transmission of signals over kilometers of distance. Multiplexed FBGs in fibers can be used for distributed sensing and can be easily installed vertically into the ground for real time and long-term monitoring of salinity (fig.2).

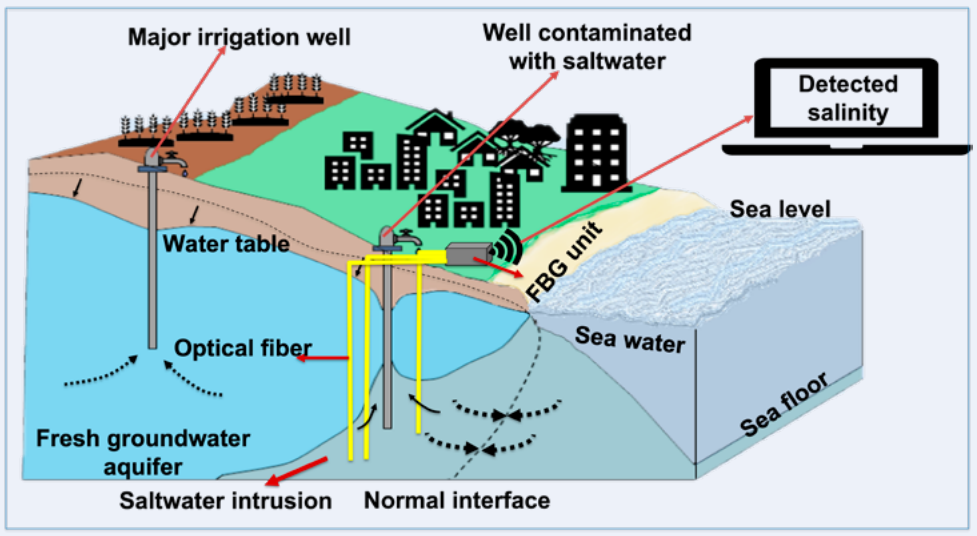

Fig 2: Remote sensing unit of FBG sensors installed for monitoring saltwater intrusion in the coastal aquifers inorder to identify quality of drinking water

Approaches

A. We will be creating a small tapered section between two identical FBGs (fig.3-A) over which the light in core mode gets coupled to the cladding modes, which are sensitive to the surrounding refractive index. The spectrum of the FBG pair shows any variation of the refractive index as wavelength shift.
B. By coating FBG with polymeric materials that swells in the presence of target ions (fig.3-B), the ions cause a change in the FBG periodicity that will be used as a chemically selective sensing tool.
C. With FBGs we can limit the excitation to a specific region of the fiber via coupling of light in and out- of the fiber core. Salt sensitive fluorophores indicates the presence of salt (fig: 3-C).

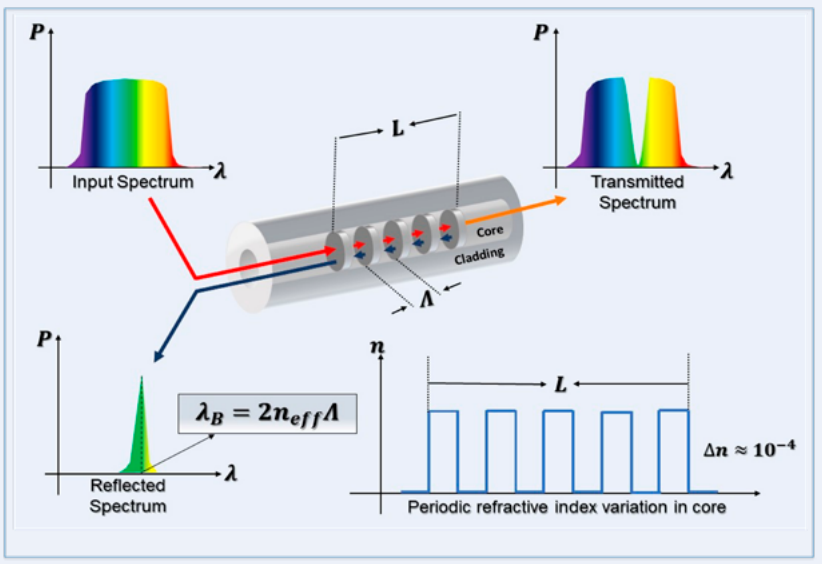

Fig 1: Principle of Fiber Bragg Gratings (FBG). Bragg reflected wavelength depends on the effective refractive index of the fiber and grating period

Research Goals

- Design salinity sensors capable of measuring low salt (NaCl) concentration in water
- Identify and test salt specific fluorophores and polymer coatings; testing durability, sensitivity and specificity
- Build the sensors with robust packaging
- Test the sensors in a laboratory set-up that mimics the changes in physical and chemical conditions in an aquifer
- Comparison studies among various approaches
- Test the FBG-based refractive index sensor in the field and assess long-term survivability

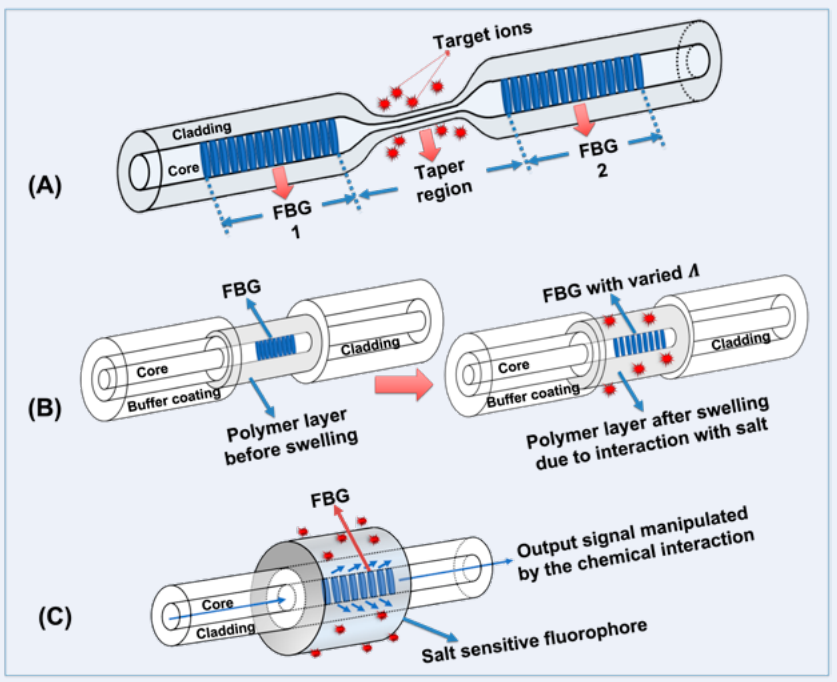

Fig 3: Approaches for target ion sensing: A) Taper seeded FBG-pair, B) Responsive polymer coated FBG, and C) Sensitive fluourophore coated FBG

References:

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[2] Werneck, Marcelo M., et al. "A guide to fiber Bragg grating sensors." Current trends in short-and long-period fiber gratings (2013): 1-24.

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