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SPEAKER SERIES
PRESENTS

High Performance Dynamic Materials in Oil Well Construction

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LECTURE ABSTRACT

A crucial component in high-performance photonic integrated circuits (ICs) and other chip-scale photonic systems is an on-chip light source that is efficient, economical, silicon (Si)-compatible, and electronically addressable. In this talk, I will cover two types of light sources with the potential to be inserted into photonic ICs: III-V nano-antenna and perovskite microlasers. I will further discuss emerging physics and applications that can be enabled by these material systems, including topological states and unidirectional edge-modes for robust data transport, and metamaterials with hyperbolic dispersion for super-resolution imaging. Oil wells are built in tough environments which challenge even the most durable and high strength materials available. Dynamic materials in wellbore operations offer the possibility of broadening the performance window of many upstream chemical processes in the oil and gas industry. These materials in oil well cementing and completions are of particular value for their ability to respond to the dynamic downhole environment with changing material properties requirements. Two products developed in our research laboratories demonstrate the practical benefits of dynamic, stimulus-responsive materials in well construction.

The first product is an oil well cement system designed for high temperatures and pressures which can undergo dynamic modifications in response to a chemical trigger, such that the setting time of the cement can be tuned as needed at the wellsite and during operations. This chemistry is based upon an advanced materials design in cement and the reversible activation of a powerful phosphonate retarding additive. Phosphates and phosphonates have been used as additive systems to modify set times in oil well cements. These two chemical groups antagonistically compete with water for binding to surface sites in the cement. While the presence of phosphonate greatly extends the induction period time in the cement, the presence of phosphate with phosphonate reduces the induction period and increases the peak hydration peak in such cement systems. The practical application of this technology offers the possibility for using a universal fluid from drilling and cementing such that oil wells may be drilled with a set delayed cement, reducing materials costs and increasing operational safety.

The second practical example of dynamic materials in oil well construction is a constitutionally dynamic covalent chemical system based upon reversible aminal / hemaminal condensation reactions which are energetically modified by the presence of trivalent salts. The interplay between equilibrium and non-equilibrium gels and liquids and the ligands responsible for these transformations has been observed rheologically to offer controlled gel times dictated by the thermodynamics and kinetics of the system. This constitutionally dynamic macromolecular system offers the possibility of harnessing an equilibrium / non-equilibrium system in tandem with its inherent self-healing and triggered release properties. The first application of this chemistry is described and presented as a high temperature / high pressure completions fluid. The application of this completion fluid offers superior thermal tolerance of existing commercially available materials in the oilfield. The findings demonstrate the suitability of this reversibly covalent chemical system as a high performance completion fluid for operations such as perforations and workovers.

SPEAKER BIOSKETCH

Dr. Boul is a senior research scientist at Aramco's Houston Research Center where his research and product development focus is stimulus-responsive polymers and nanomaterials. Dr. Boul earned a PhD from Rice University in chemistry under the tutelage of Professor Richard E. Smalley. Following a postdoctoral stint with Professor Jean-Marie Lehn in Strasbourg in dynamic materials, Dr. Boul has led product development activities in advanced materials design at NASA, Halliburton, and Aramco. Dr. Boul has published over 40 peer-reviewed papers and patents in these fields.