Deuterated Silicon Photonic Waveguides for Optical Signal Processing

**Description**

Next generation optical networks will rely heavily on all-optical signal processing (OSP) in integrated photonic platforms to meet demands of greater bandwidth, larger network flexibility, lower energy consumption, and lower costs [1, 2]. An ideal platform has high optical nonlinearity and low losses while maintaining compatibility with complementary metal–oxide–semiconductor (CMOS) fabrication technologies. Crystalline silicon (c-Si) is CMOS compatible but its applicability is limited due to high two-photon absorption (TPA) losses due to a narrow electronic bandgap in the telecommunication wavelength region (~1.5 µm); hence, high parametric gain is not achievable [3].

A promising alternative platform is amorphous silicon (a-Si). To date, a-Si films passivated with hydrogen (a-Si:H) have been applied for OSP. Hydrogenated a-Si is typically deposited using plasma-enhanced chemical vapor deposition, a fully CMOS compatible process. Tuning the deposition parameters allows tailoring of the bandgap to minimize TPA at 1.5 µm. Hydrogenated a-Si also has the highest nonlinearities of any demonstrated integrated CMOS compatible material [4], making it ideally suitable for OSP.

It remains a major challenge, though, that a-Si:H is not stable under the moderate optical powers needed for ultra-high speed, efficient, and stable OSP. This is due to the well-known Staebler-Wronski (SW) effect, an electronically-assisted degradation mechanism which creates dangling bonds that increase the total absorption losses [5]. In the late 1990’s it was found that exchanging H in a-Si:H with deuterium (D) to create a-Si:D reduces the SW effect, consequently stabilizing and improving the device performances [5]. Surprisingly, the question of how a-Si:D waveguides perform in photonics remains unanswered!

**Goals of the project**

In this project, you will investigate the unique effects of exchanging hydrogen with deuterium in a-Si:H waveguides for creating a stable nonlinear photonic platform and utilize the waveguides in OSP experiments in collaboration with the high-speed optical communications (HSOC) group and the center for silicon photonics for optical communications (SPOC). If successful, such a platform would have the highest nonlinearity of any CMOS-compatible material to date and would open up avenues of research in ultra-fast and broadband optical signal processing, supercontinuum- and frequency-comb-generation with perspectives within on-chip data-communication, spectroscopy, metrology, and quantum information.

**Skills / knowledge acquired in the project**

In the project, you will be a team member of the SPOC center and the project will provide you with in-depth knowledge on the fabrication and utilization of silicon photonics for optical signal processing applications. The project will give you hands-on experience with state-of-the-art silicon fabrication and characterization technologies utilized at DTU Danchip and DTU Fotonik.

**Recommended / optimal prerequisites**

34020 Optics & Photonics / 34041 Waveguide Optics / 34130 Introduction to Optical Communication / 34129 Experimental Course in Optical Communication / 33255 Fabrication of Micro- & Nano Structures / 3347X Nano-3W

**Responsible persons**

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