**Bidirectional Widely Tuneable 1310 nm MEMS VCSEL**

Masoud Payandeh, Hitesh Kumar Sahoo, Elizaveta Semenova, Kresten Yvind

Recent advancements in swept-source optical coherence tomography (SS-OCT) have leveraged continuous-wavelength tunable light sources, notably micro-electro-mechanical system-based vertical cavity surface emitting lasers (MEMS-VCSELs). Our devices incorporate a highly reflective DBR mirror and a high-contrast grating (HCG) mirror, combined with III-V active region, to define the MEMS VCSELs' optical cavity. The actuation of HCG mirror facilitates changes in the optical cavity length, resulting in the continuous tuning of the emitted wavelength. The axial resolution in OCT is inversely proportional to the tuning range, necessitating a wide tuning capability. Bidirectional tuning lasers are able to offer expansive linear tunability. MEMS VCSEL devices feature two cavities: a semiconductor cavity housing the active region and an air cavity, exhibiting strong coupling. The tuning ratio can be adjusted by controlling the interaction between the air and semiconductor regions. Three configurations—semiconductor-coupled cavity (SCC), extended cavity (EC), and air-coupled cavity (ACC)—are compared for 1310 nm MEMS VCSELs, with the EC structure showing a compromise between SCC and ACC designs with a 140 nm linear tuning range. In addition, our MEMS VCSEL structure is a bidirectional tunable laser based on a movable HCG mirror fabricated in silicon (SOI) in a sealed cavity. We fabricated the SCC MEMS-VCSEL through vacuum bonding of an epitaxial InP wafer to a patterned SOI wafer to have very low pressure in the sealed cavity around the MEMS membrane. We achieved 79 nm tuning at 1.5 MHz frequency for this structure.