Chip-scale Cavity Electro-optomechanics with Aluminum Nitride

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Chip-scale cavity optomechanics studies photon–phonon interaction on an integrated platform. It offers unparalleled displacement sensitivity allowing the control of mechanical resonators at quantum level. The dynamic cavity backaction can be utilized to cool a mechanical resonator to its ground state or amplify its motion to limit-cycle oscillations. Optomecchanical system can be also coupled to electrical degree of freedom to form cavity electro-optomechanical system, where microwave signals and optical signals are coupled through a common mechanical resonator. Such a hybrid platform can provide strong electrical actuation and ultra-sensitive optical readout in a single device.

Aluminum nitride (AlN) is the ideal material to realizing such a hybrid platform. High quality optical cavities and mechanical resonators can be fabricated with CMOS compatible fabrication procedures. Beside low optical and mechanical losses, AlN possesses strong piezoelectric effect due to the wurtzite crystal structure, which gives rise to strong coupling between mechanical resonators and microwave cavities. Here we will review our recent progress in developing integrated AlN optomechanical devices. Several device designs including optomechanical crystal (Figure 1), micro-disk (Figure 2), and micro-wheel (Figure 3) are introduced. These high performance devices make it possible to realize coherent signal manipulations among optical, microwave and mechanical domains. Examples include optical amplification and absorption, optomechanical induced transparency, cascaded optical delay etc.

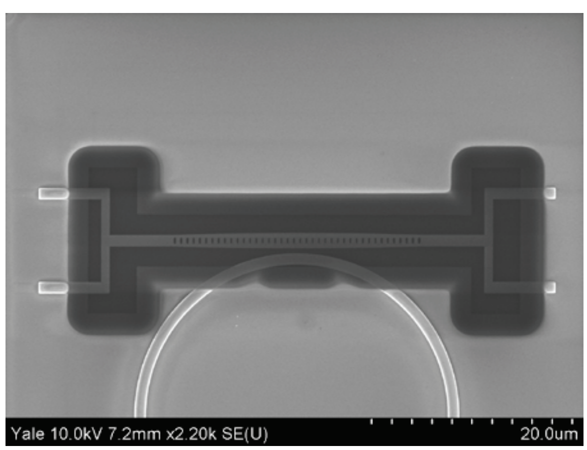

Figure 1. Optomechanical crystal cavity fabricated with AlN

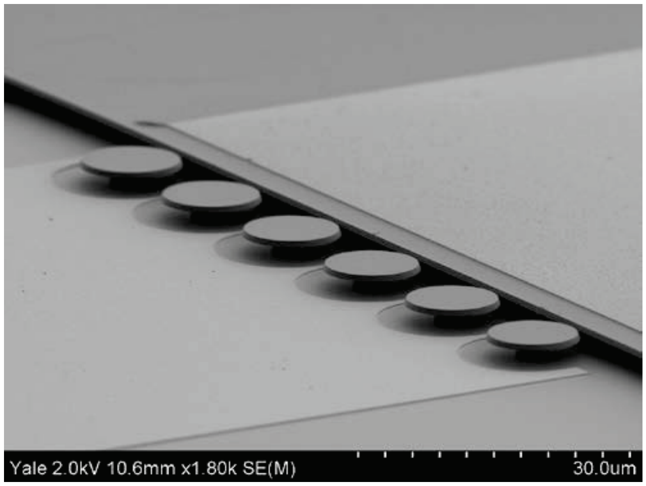

Figure 2. Optomechanical micro-disk fabricated with AlN

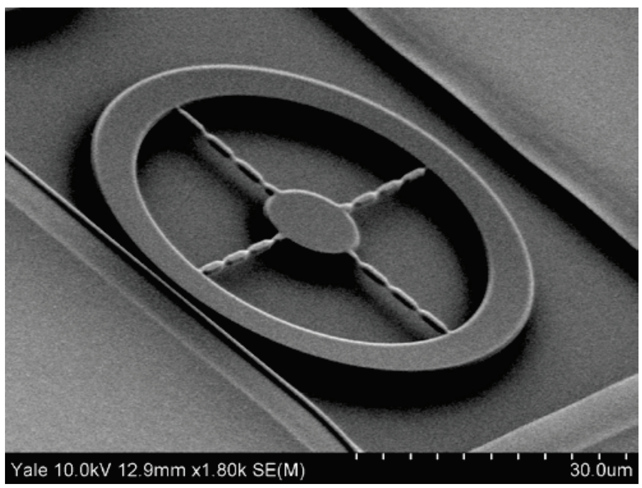

Figure 3. Optomechanical micro-wheel fabricated with AlN