Measuring thermal expansion of graphene and understanding modal dispersion at low-temperature using graphene NEMS resonators

MANDAR DESHMUKH, VIBHOR SINGH, SHAMASHIS SENGUPTA, HARI S. SOLANKI, ROHAN DHALL, ADRIEN ALLAIN, SAJAL DHARA, Tata Institute of Fundamental Research, Mumbai, India 400005, PRITA PANT, Department of Materials Science, Indian Institute of Technology, Mumbai India 400076 — We use suspended graphene electromechanical resonators to study the evolution of resonant frequency as a function of temperature. Measuring the change in frequency resulting from a change in tension, from 300K to 30K, allows us to extract information about the thermal expansion of monolayer graphene as a function of temperature, which is critical for strain engineering applications. We find that it is negative for all temperatures between 30K and 300K. We also study the dispersion of the electromechanical modes due to the application of a DC gate voltage and find a high degree of tunability of resonant frequency, desirable for applications like mass sensing and RF signal processing at room temperature. With lowering of temperature, we find that the positively dispersing electromechanical modes evolve to negatively dispersing ones. We quantitatively explain this crossover and discuss optimal electromechanical properties that are desirable for temperature compensated sensors.