Feasibility of CMOS Phonon Laser

Kazuhide Abe
Corporate R&D Center, Toshiba Corp., Kawasaki 212-8582, Japan
kazuhide.abe@toshiba.co.jp

Recently, stimulated emissions of phonon have been experimentally demonstrated by Grudinin et al. using optical ring resonators [1], and by Beardsley et al. using quantum wells of super-lattice [2]. Whereas both the groups used light as energy source, Chen et al. have proposed a “phonon laser” using hot carriers, which are accelerated by electric field between drain and source in metal-semiconductor field-effect transistor (MESFET), as the energy source to create coherent phonon [3]. This paper preliminarily demonstrates feasibility of phonon laser using n-channel MOSFET with multi-finger gate structure [4]. LO phonon is assumed to be created through stimulated emission in impact ionization process of hot carriers [Figs. 1(a) and (b)] followed by decay of the LO phonon into two LA phonons causing acoustic resonance. A coherent resonance at 300 MHz was experimentally observed in frequency dependence of impedance ($R+iX$) measured for the p-well terminal [Fig. 1(c)]. Quality factor was estimated to be higher than 1500, suggesting that the hole creation in impact ionization process is synchronized with the acoustic resonance.


Fig. 1 Model of stimulated phonon emission by hot carrier (a), (b), and sharp resonance ($Q>1500$) observed for p-well terminal (c).

| $V_{g}$ | 1.2 V | $R_{\text{max}}$ | 290 Ω |
| $V_{d}$ | 1.2 V | $R_{\text{min}}$ | -55 Ω |
| $Z=R+iX$ | | $Q=1,580$ |  |