Terahertz plasma oscillations in Corbino field-effect transistors

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Semiconductors whose plasma frequency falls in the terahertz range are attractive candidates for THz generation and detection. A mechanism of plasma-wave instability was suggested by Dyakonov and Shur [1] who noticed that plasma waves in the channel of a field-effect transistor (FET) can become unstable when propagating between the transistor's contacts.

The Dyakonov-Shur instability relies heavily on the boundary conditions at the source and the drain of the FET. In their original publication, Dyakonov and Shur postulated two asymmetric boundary conditions: zero ac potential at the source and zero ac conduction current at the drain. Although other boundary conditions have been studied subsequently, their asymmetry has been considered necessary for the instability to occur. Practical realisation of asymmetric boundary conditions is, however, a formidable problem, especially at terahertz frequencies. For example, the authors of Refs. [2,3] suggested that it can be realized by driving the transistor in saturation, but they also admitted that the original theory of Dyakonov and Shur may not work in this regime.

We have taken an alternative approach to the plasma instability in a FET. Instead of relying on the mathematical asymmetry of the boundary conditions, we have considered a geometrically asymmetric structure shown in Fig. 1(a). In this geometry, known as a Corbino FET, the source and the drain are two concentric electrodes. The geometrical asymmetry in the Corbino FET allows the plasma instability to occur even at symmetric boundary conditions. Figures 1(b) and (c) show the real and imaginary parts of the lowest-order eigenfrequency when the ac voltage is zero at the source and at the drain. In the presence of electron drift, the plasma oscillations are unstable, as indicated by negative values of the imaginary part of the eigenfrequency. The instability increment is larger for smaller sources and can exceed that in the rectangular FET. The presentation with further discuss the dependence of the instability increment on various parameters as well as the voltage and current distributions. These properties could make the Corbino geometry advantageous for realization of practical THz oscillators.

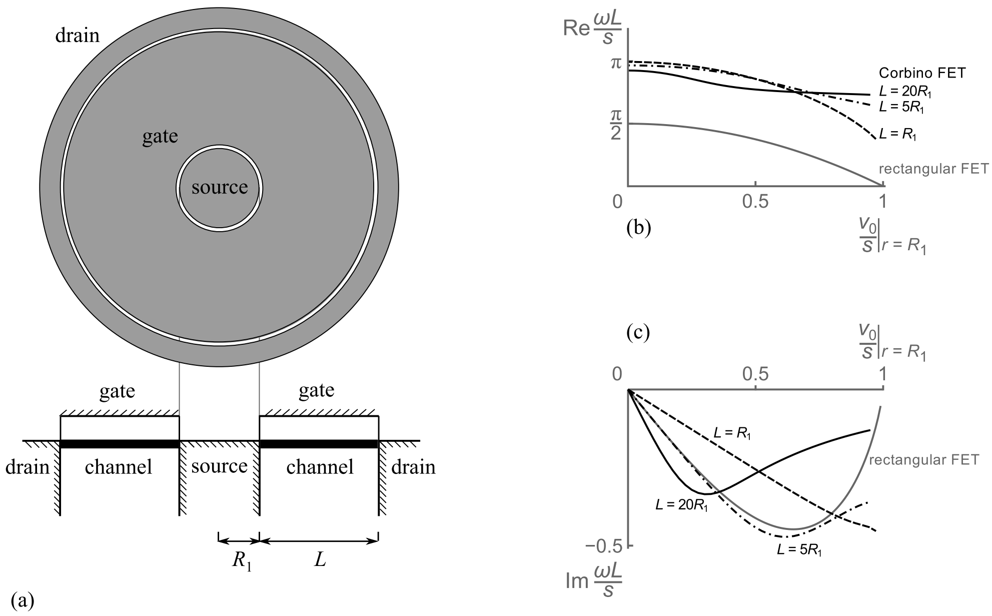

Fig. 1 (a) The Corbino FET (top- and side-view) has concentric source and drain and a top gate. Real (b) and imaginary (c) parts of the lowest eigenfrequency of plasma oscillations in the Corbino FET depending on the drift velocity at the source. Negative imaginary parts indicate unstable oscillations, which can be used for THz generation.

References

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