Realizing Asymmetric Boundary Conditions for Plasmonic THz Wave Generation in HEMTs

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***Abstract*—In this work, we realized the requisite asymmetric boundary conditions across a plasmonic cavity, which is formed inside the gated region of a high electron mobility transistor (HEMT), to trigger the Dyakonov-Shur plasma wave instability.**

I. INTRODUCTION

Devices utilizing plasma wave generation are promising candidates for the realization of compact solid-state sources capable of operating efficiently at THz frequencies. Plasma wave generation can occur when the current flowing through a device exceeds a threshold value, allowing initial plasma excitation produced by ambient noise to be amplified after reflection from the edges of plasmonic cavity formed under a statically biased gate [1]. In order to observe such amplification, however, the impedance at the ends of the cavity should be highly asymmetric, i.e. low at the source and high at the drain [1, 2]. While significant experimental effort has focused on implementing plasmonic THz devices, the power radiated into free space has proven to be too weak for practical use. One of the main reasons for this problem is the difficulty in creating asymmetric cavity boundaries. To address this issue, in this work, we show that etching a constriction near the gated region of a HEMT (at a distance of ~100 nm) can produce the high impedance required on the drain side of the cavity, thus yielding the requisite asymmetry needed to trigger plasma-wave amplification.

II. RESULTS

Our devices are fabricated on an InP based InGaAs/InAlAs heterostructure, in which the constriction is defined by wet etching. The onset of plasma-wave amplification is manifested in transport measurements, as an additional dissipation channel that causes a small but sudden drop in the DC current through the channel (Figs. 1 & 2). The significance of the boundary conditions manifests itself when the current direction is reversed (thereby reversing the cavity boundary conditions). In this case, the current instability of Figs. 1 & 2 is no longer observed.

III. SUMMARY

Our work demonstrates reliable asymmetric boundaries required for plasma wave amplification and provides an important step to the realization of compact solid-state THz plasmonic transmitters.

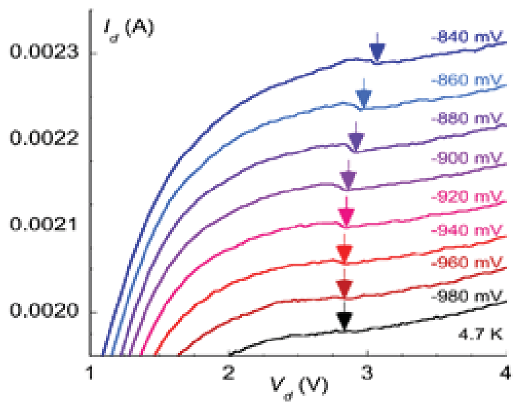

Fig. 1. Electrical characteristics of an InGaAs/InAlAs FET with plasmonic cavity and asymmetric boundaries (at 4.2 K). The figure shows the I-V characteristics obtained with various gate voltages. Arrows denote the presence of a current instability that shifts systematically with variation of the gate voltage.

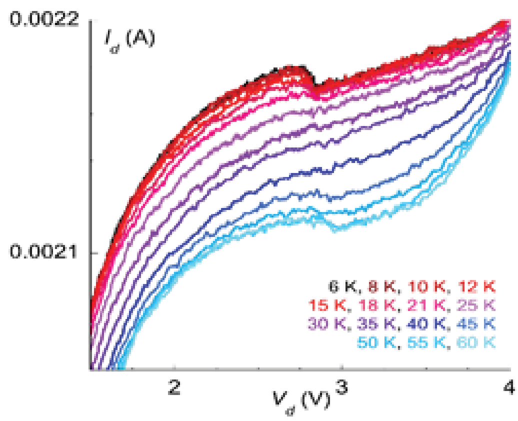

Fig. 2. Temperature dependence of the instability, demonstrating its survival to temperatures approaching those of liquid nitrogen.

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978-1-5386-8285-2/19/$31.00 ©2019 IEEE