3.2 **Superradiant plasmonic lasing in population-inverted graphene**

When a grating-type (Bragg grating, TM wave平行gate方向) gate stack is incorporated into planar graphene such as in an asymmetric dual-grating-gate graphene-channel field-effect transistor (ADGG-GFET) structure (see Fig. 8(a)), the gain is resonantly and cooperatively enhanced [51].

The graphene could be pumped either by optical pumping or by the injection of the electrons and holes from the ADGG electrodes.

If the ADGG-GFET is installed in a Fabry-Perot-like vertical photonic cavity, the spontaneously emitted THz photons will be fed back to graphene, stimulating the resonantly SPP-induced THz emission.

If the Fabry-Perot longitudinal modes match the 2D plasmon modes, the cooperative stimulated plasmon/photon emission of THz radiation should result in an intense THz lasing.

The carrier population and hence the graphene optical conductivity are characterized by the quasi Fermi levels and carrier temperature.

The SPPs in different graphene microcavities oscillate in phase (even without the incoming electromagnetic wave) , because the metal contacts act as the synchronizing elements between the adjacent graphene microcavities.

Such an asymmetrical boundary condition may promote the Doppler-shift-type Dyakonov-Shur (DS) plasmonic instability .

higher velocity underneath G2 and a lower velocity underneath G1. Thus high-velocity electrons are injected to the low velocity plasmonic cavity region which may excite the plasmons in a resonant manner.

\*Ryzhii-Satou-Shur (RSS) plasmonic instability

\* Dyakonov-Shur (DS) plasmonic instability

Linear and gapless energy spectrum of graphene carriers enables population inversion under optical and electrical

pumping giving rise to negative dynamic conductivity in a wide THz frequency range.

Poor overlapping and low quantum efficiency (limited by the interband absorption coefficient of 2.3%) could be resolved by using the graphene SPPs that could dramatically enhance the THz gain due to their nonlinear slow-wave nature.

The graphene-SPP instability driven light amplification of the stimulated emission of the THz radiation is feasible.

Integrating the graphene SPP oscillator/amplifier into a current-injection graphene THz laser transistor will be a possible smart solution towards achieving the room-temperature intense THz lasing.