



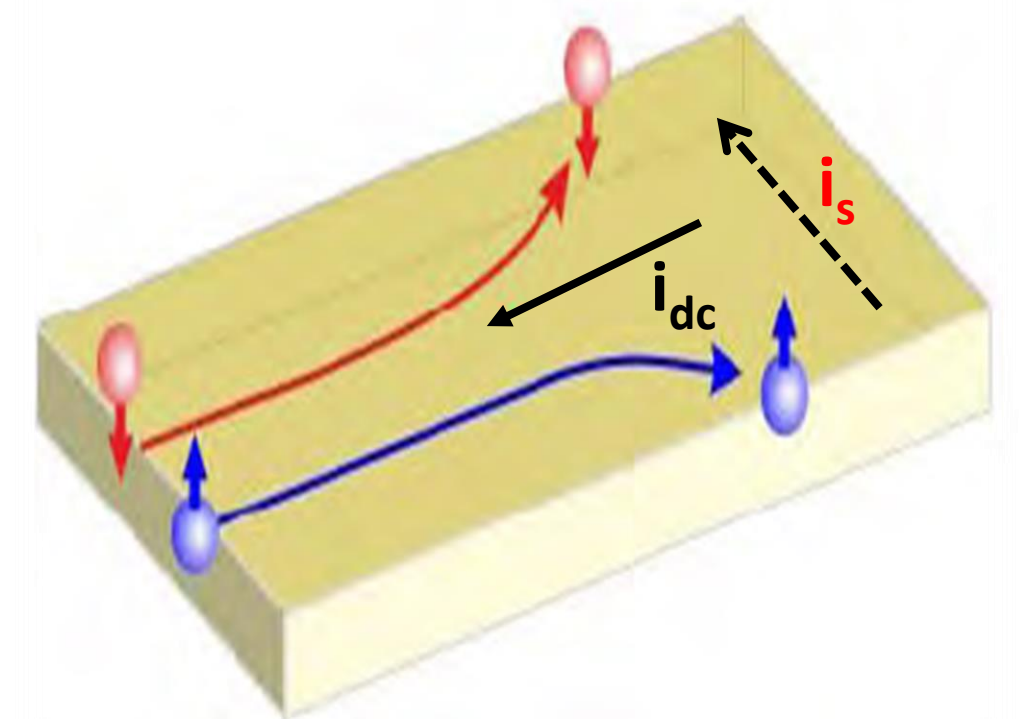
Enhancing the Microwave Signal by Combining the Spin Transfer Torque and Spin Hall effect in Nano-oscillator Devices

Technological Physics Engineering

Mohammad Tarequzzaman (tareq.zaman@inl.int)

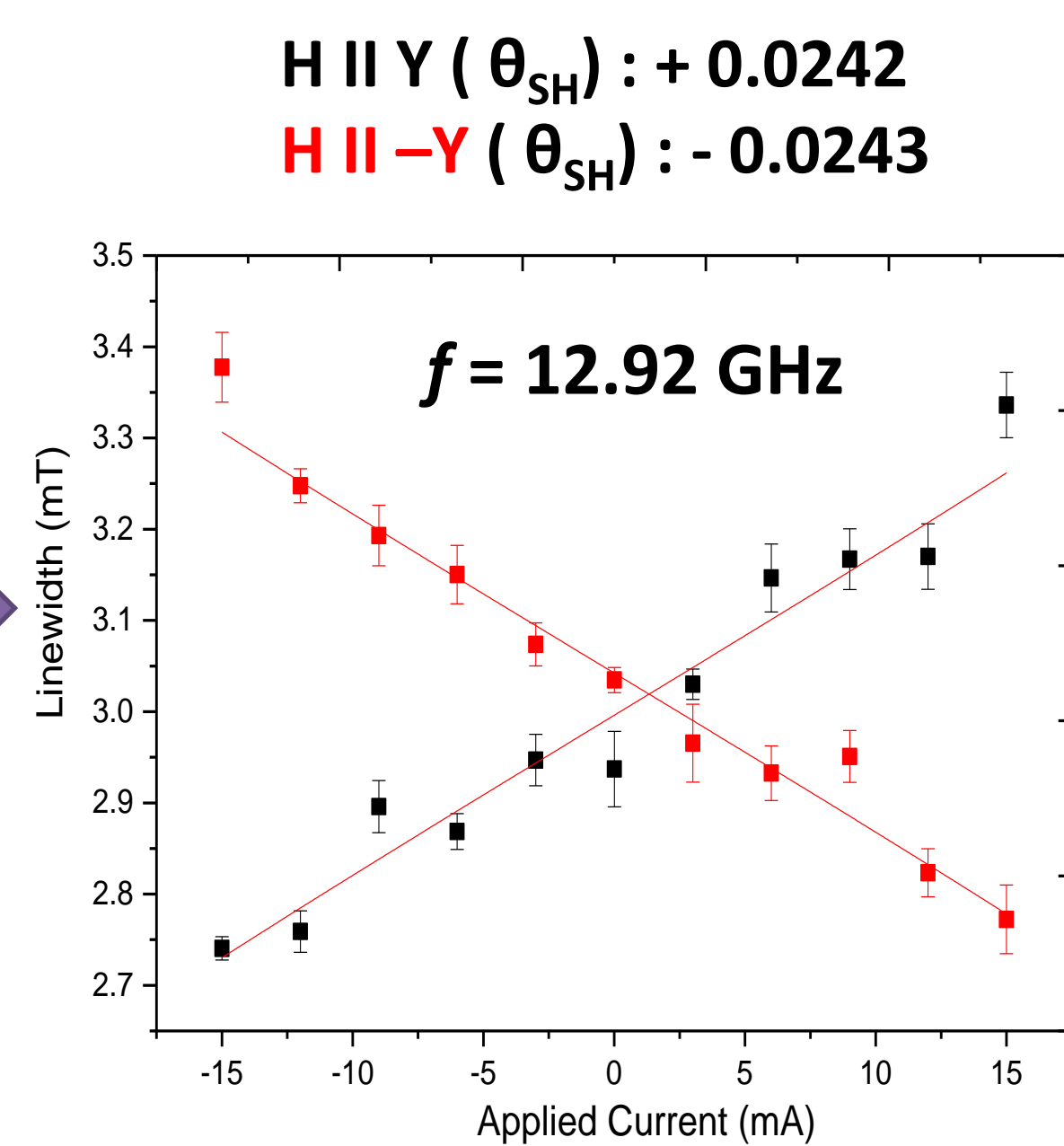
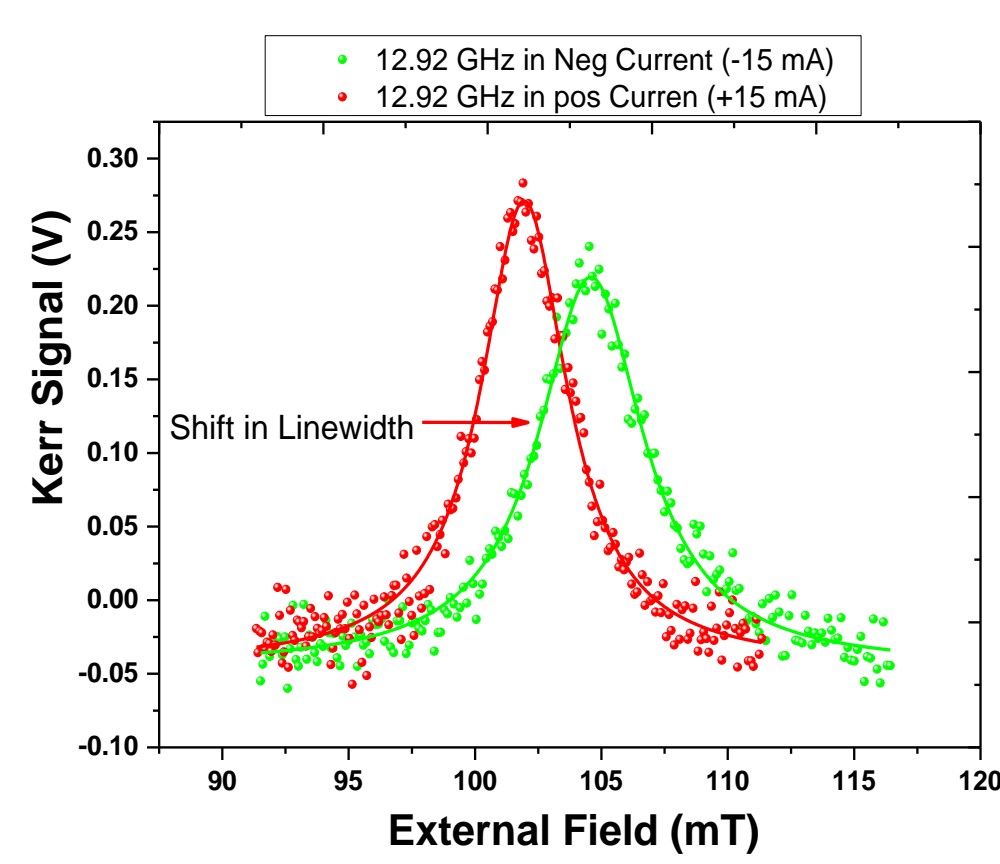
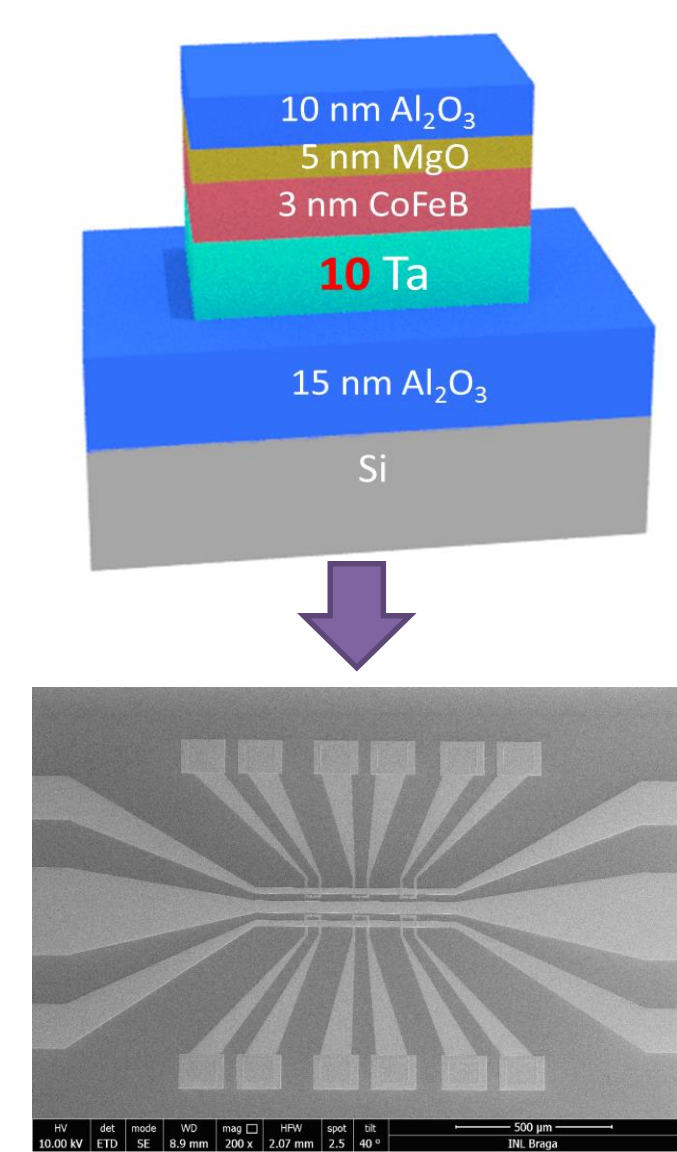
Introduction

Pure spin currents generated by the Spin Hall Effect (SHE) have recently been used to dynamically excite the free layer magnetization in 3-terminal MTJ devices. This configuration is very attractive from an application point of view since the electrical current used to inject spin in the free layer does not tunnel through the MgO. Thus, issues related to the tunnel barrier degradation and dielectric breakdown which end up limiting the amount of spin current density that can be injected in the free layer are avoided. However, there are very few experimental results demonstrating an electrical detection of dynamics from pure spin currents in 3-terminal devices and the output power attained by Nano-Oscillators in such a configuration is relatively low compared with that obtained in conventional 2-terminal STNOs relying on polarized tunneling currents.

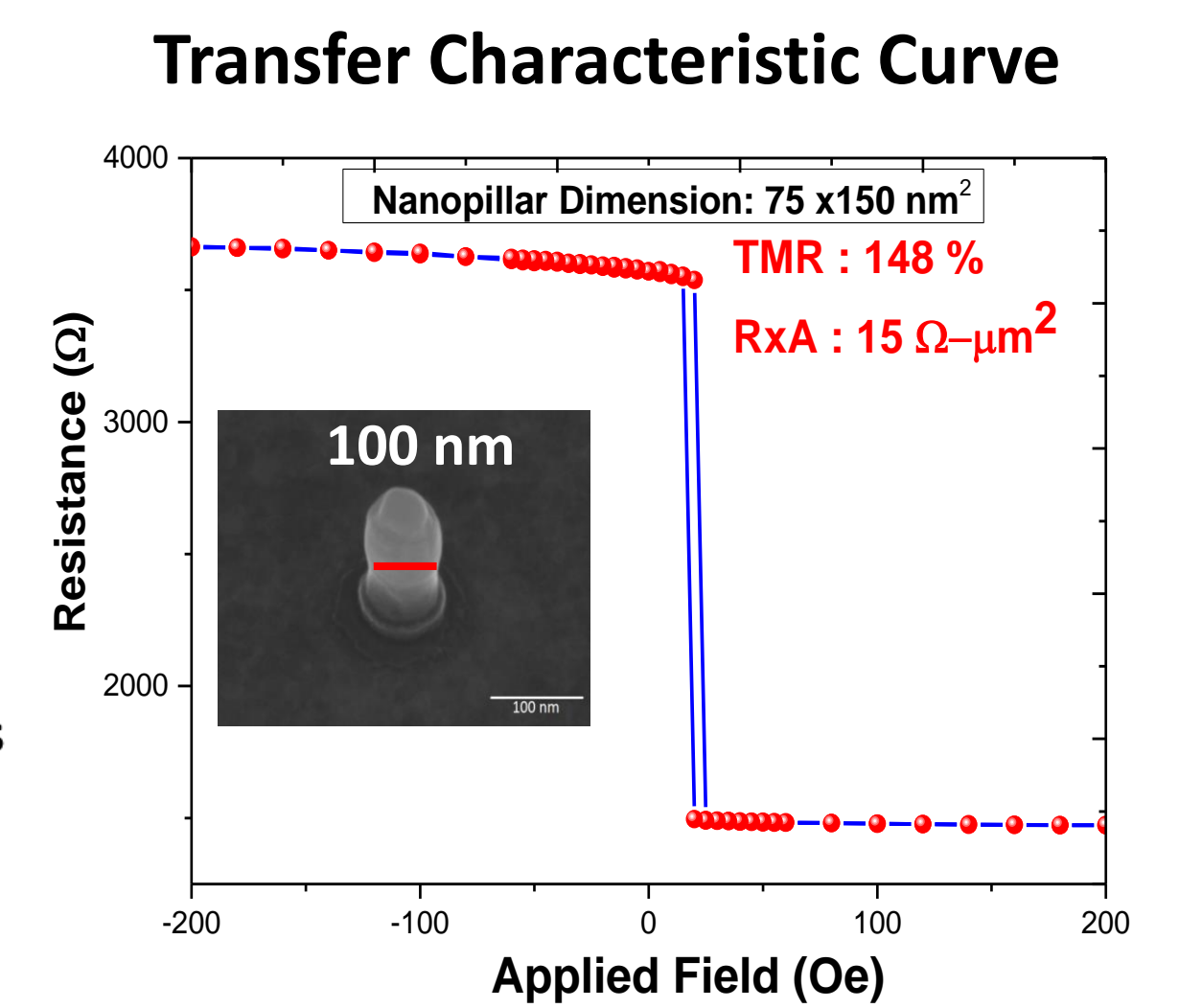
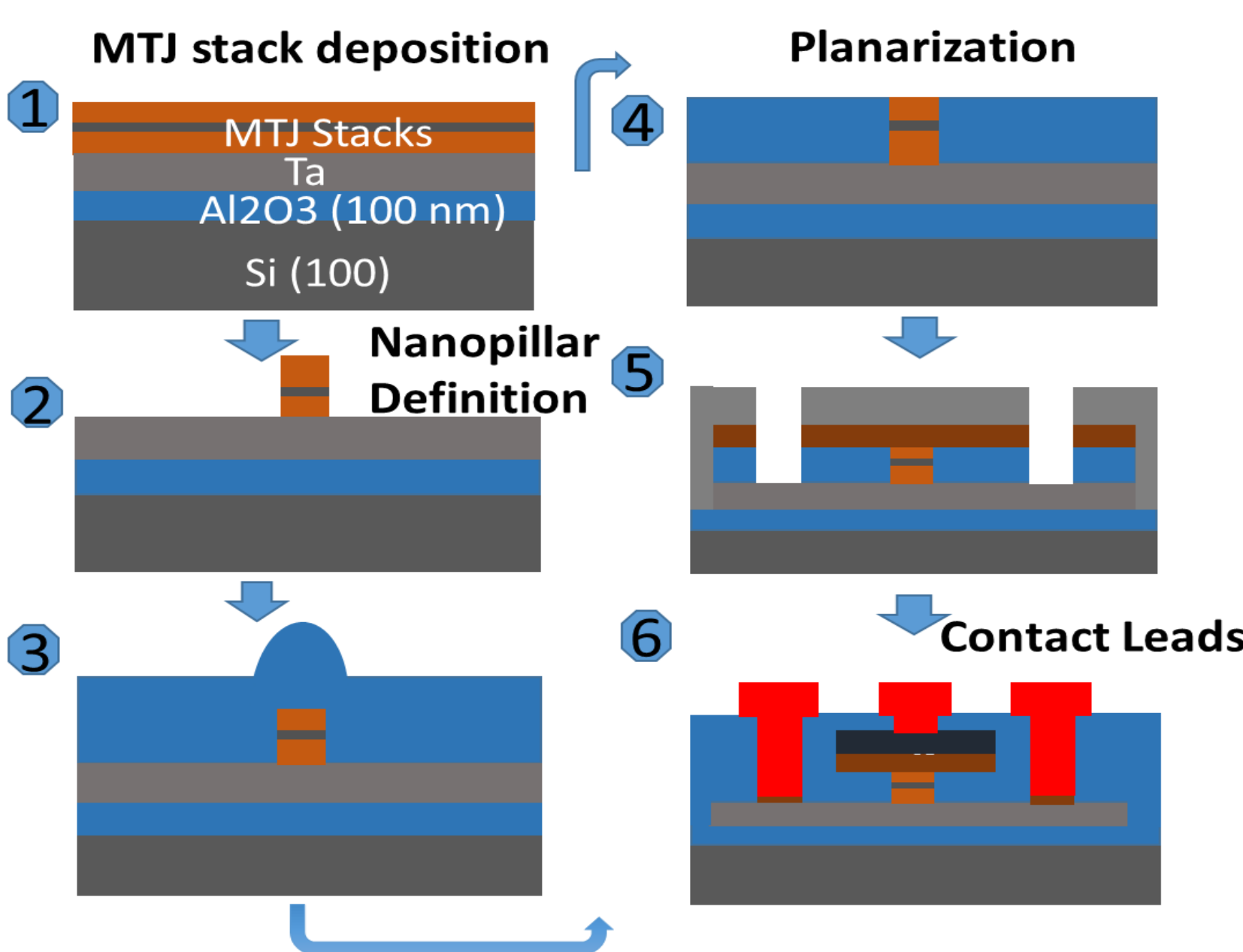


Spin Hall Angle Measurement & Micro & Nano-fabrication

Micro-fabricated Stack

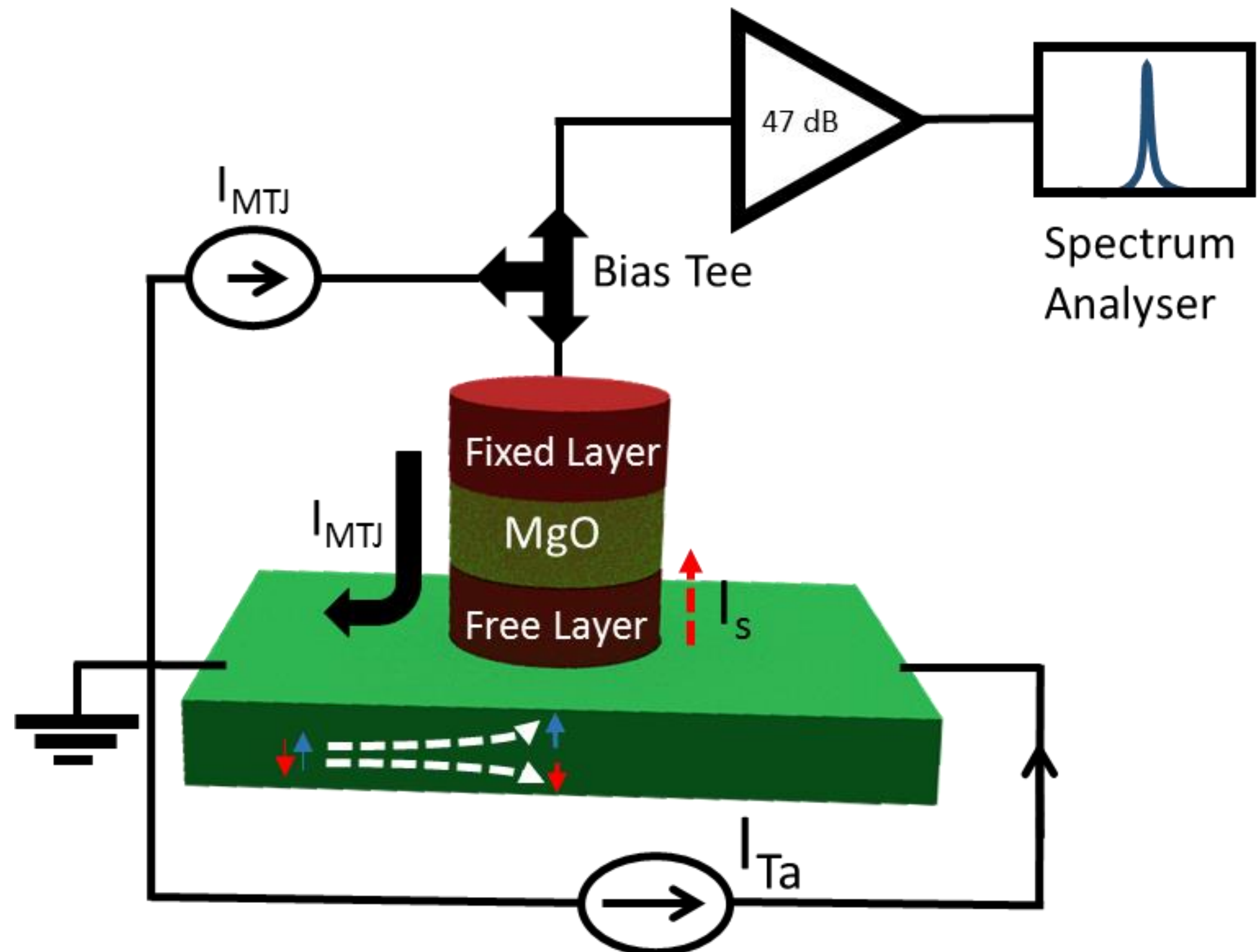


Fabricated Stack: Si/ 100 nm Al₂O₃/ 15 nm Ta / 1.4 CoFe₄₀B₂₀ / MgO [12.1 Ω·μm²] / 2.2 CoFe₄₀B₂₀ / 0.85 Ru / 2 CoFe₃₀ / 20 IrMn / 5 Ru / 140 Cu / 30 Ru

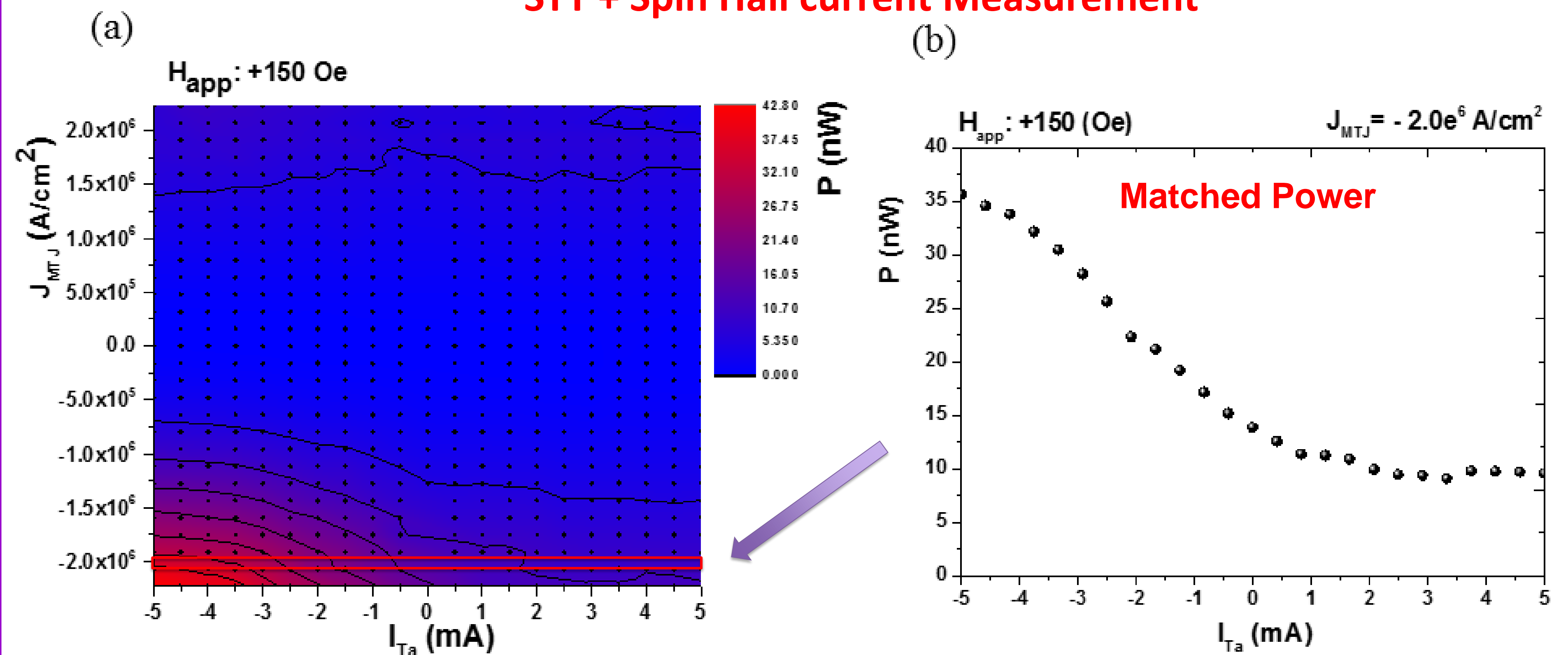


Spin Hall Induce Oscillations

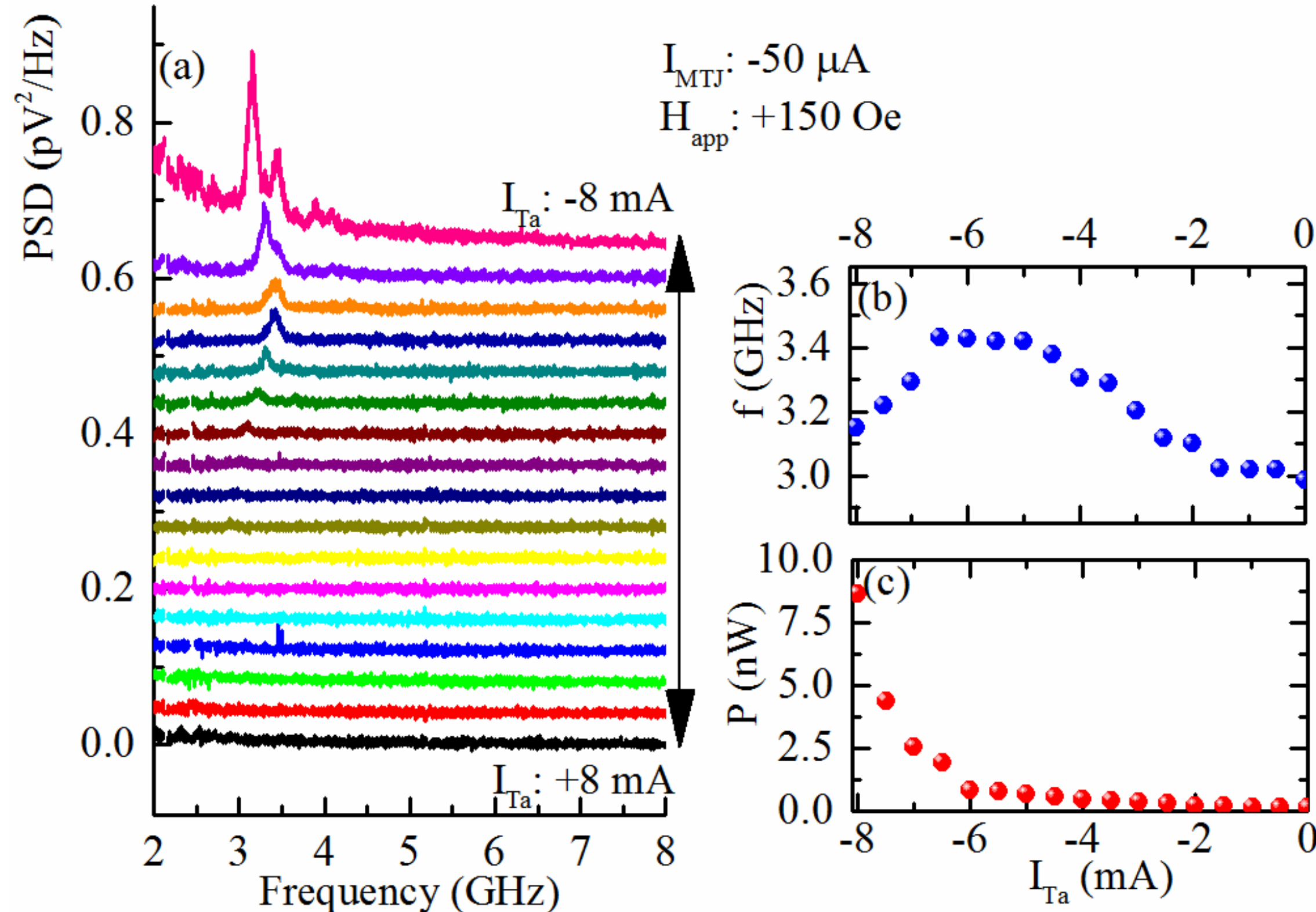
SHNO Measurement Setup



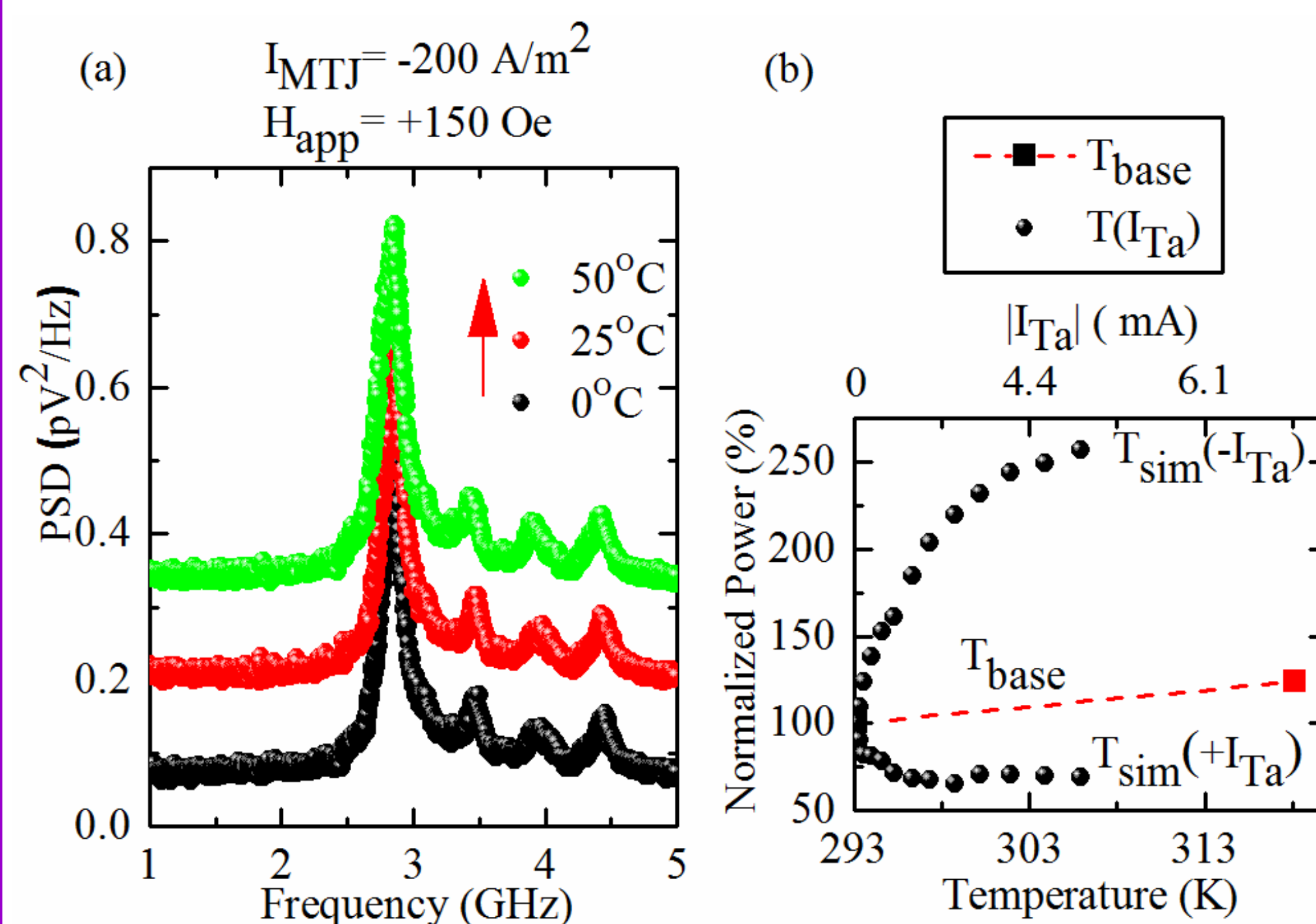
STT + Spin Hall current Measurement



Pure Spin current Measurement



Temperature Dependent Measurement



Conclusion

INL Device Results

- (i) Spin Hall Angle ($\theta_{SH,Ta}$) = $2.4 \pm 0.14\%$.
- (ii) Emitted Power P_{out} : up to 8.6 nW (Power delivered to Load) & combine power around 40 nW (Matched Power) (STT+SHNO)
- (iii) Linewidth (L): Down to 150 MHz
- (iv) Operation Frequency (f): 2.5 – 3.5 GHz