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MICROWAVE APPLICATIONS OF STOs

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Spin Torque Oscillators (STOs) deliver a microwave signal, the frequency of which can be controlled by the injected current. Up to now, agile frequency sources are usually provided by Voltage Controlled Oscillators (VCOs) based on a voltage dependent capacitor (varactor or varicap diode). The tuning range and the spectral purity of these sources is somehow limited by the C(V) and the moderate quality factor of the diode. The best sources for both these points are based on FerroMagnetic Resonance (FMR) and use a small sphere of Yttrium Iron Garnet single crystal (YIG). They are known as YTO for YIG Tuned Oscillators. The quality factor of YIG spheres is typically two orders of magnitude higher than the one of diodes, and the FMR frequency can be swept over two octaves (versus less than one for diodes).

For YTOs, the phenomenon used is the spin resonance. The damping by magnon-phonon process is intrinsically low (less than 10^{-4} Kasuya, Le Craw, Spencer), and the line broadening due to magnon-magnon interaction is mediated by crystal defects. Thus for perfect crystals, high quality factors (10 000) can be reached. The magnetic bias is applied by an external magnet without any contact and thus with very low extra loss. The signal is also coupled through a contactless conducting loop inducing low loss.

The main drawback of the YTO is the control of the FMR by a magnetic field which requires a bulky electromagnet. Thus YTOs are slow (several milliseconds), power consuming and cannot be integrated in the circuits. Nevertheless their outstanding capabilities make them indispensable for many systems.

The interest of STOs is to obtain the properties of FMR with an integrated electric current command. Up to now, the linewidth is much broader for STO than for YIG and the power is several orders of magnitude lower. The broadening of the linewidth is probably due to defects in the structure, the ultimate value is limited by electron magnon processes in metals and is typically one order of magnitude larger than the linewidth of YIG (which is an insulator limited only by magnon-phonon processes). Nevertheless the disk shape of the active part of the STO is favorable because the uniform precession is located at the bottom of the spin wave manifold and magnon-magnon processes are theoretically forbidden. As to the power level, YTOs can deliver several milliwatts, first because the power is provided by a transistor which is coupled to the resonant YIG sphere, and the energy density in the resonator is much lower since the volume of the sphere is about one tenth of cubic millimeter compared to cubic nanometers for the STO. Thus synchronization of STOs is essential for applications if we want to reach milliwatt level with a high spectral purity (which prevents a simple amplification of a microwatt signal).