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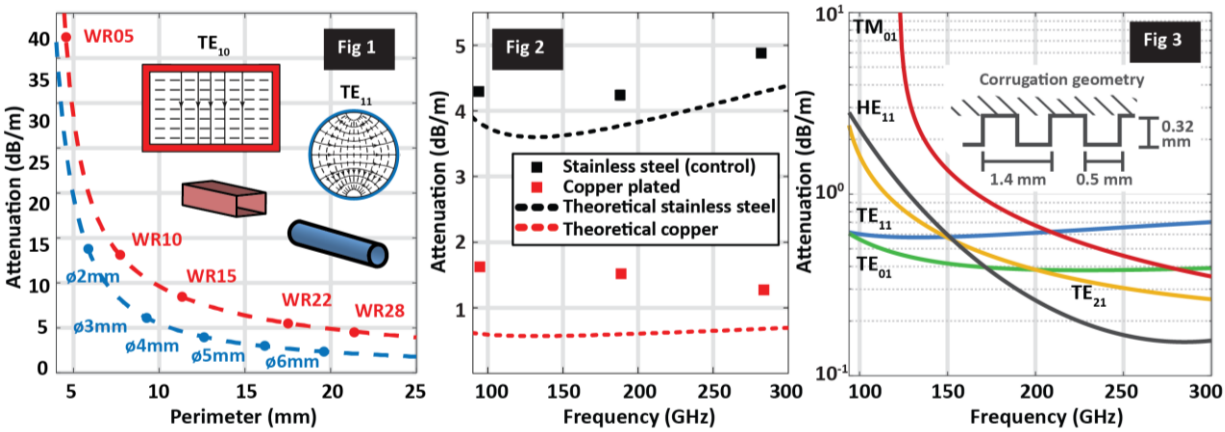
Since the early demonstrations of dynamic nuclear polarization (DNP), microwave irradiation has been a requisite to transfer electron spin polarization to nuclear spins. Significant increase in NMR sensitivity by way of dissolution DNP (dDNP) [1] has encouraged the development of multiple commercial and home-built polarizing systems and consequently dDNP probes. The length of waveguide needed to couple a microwave source to the electron spins is dictated by the dimensions of the 'polarizer', thereby influencing the total waveguide attenuation. Additionally, the desire for higher magnetic fields (B_0) has raised the required microwave frequency to perform DNP, further limiting the available power due to inefficient solid-state microwave sources. Corrugated waveguides improve microwave irradiation by reducing transmission losses, but are costly to procure [2]. Similarly, mode converters offer use of propagation modes with reduced attenuation constants, but are challenging to fabricate at higher frequencies.

We herein present a solution to achieve efficient microwave irradiation as implemented for the dDNP probe in our most recent polarizer. The probe is permanently equipped with a waveguide coupling the top flange of the probe to the cryogenically cooled sample space, thus causing a ~290 K thermal gradient. To improve thermal isolation, a circular stainless steel waveguide (⌀4.16mm) is selected, since it offers the lowest attenuation to perimeter ratio, Fig 1. Ohmic losses are reduced by internally electroplating the waveguide with a 2-3 µm layer of copper. Waveguide attenuation was characterised for frequencies 94, 188 and 282 GHz, Fig 2. The attenuation of the lowest four modes in the copper plated waveguide is given in Fig 3, including HE_{11} in an equivalent stainless steel waveguide with aluminium corrugation [2]. Fig 3 illustrates that the TE_{11} fundamental mode is a good choice with little incentive to use corrugated waveguides or mode converters. In conclusion, less than 1 dB loss can be achieved across the frequency range 94-282 GHz with a low cost, simple to manufacture circular waveguide.



[1] J. H. Ardenkjaer-Larsen *et al.*, *Proc. Natl. Acad. Sci.*, 100, 18, 10158-10163 (2003).
[2] E. de Rijk *et al*. Rev. Sci. Instr., 82, 066102 (2011).