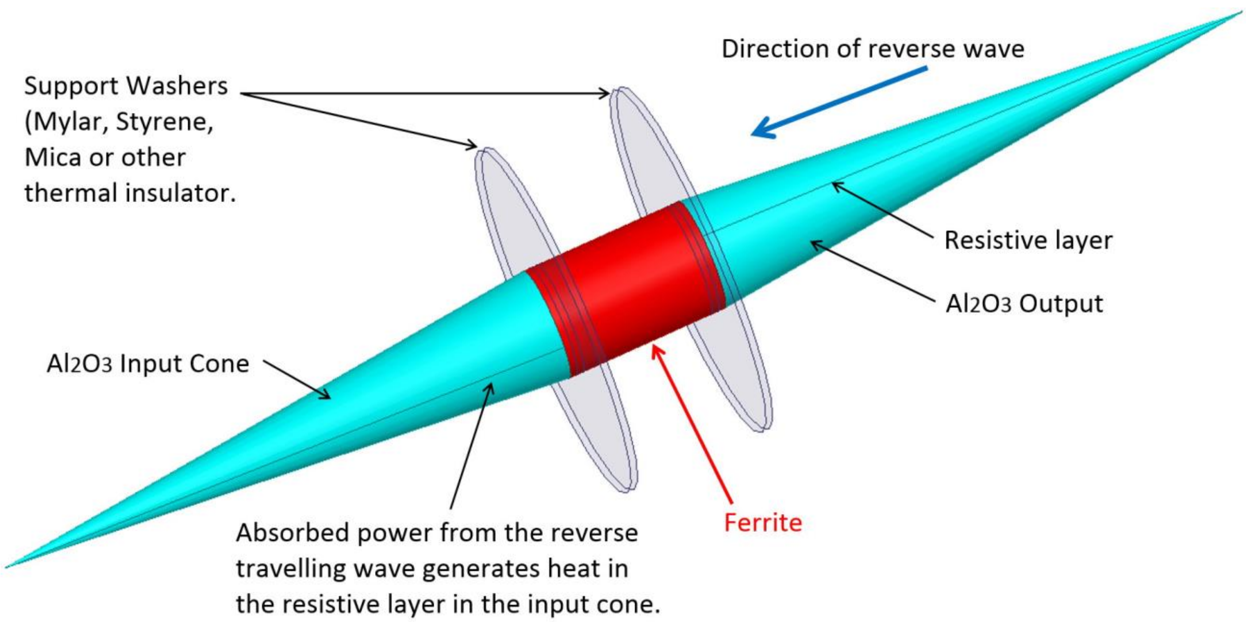
Diamond Heatsink Technology

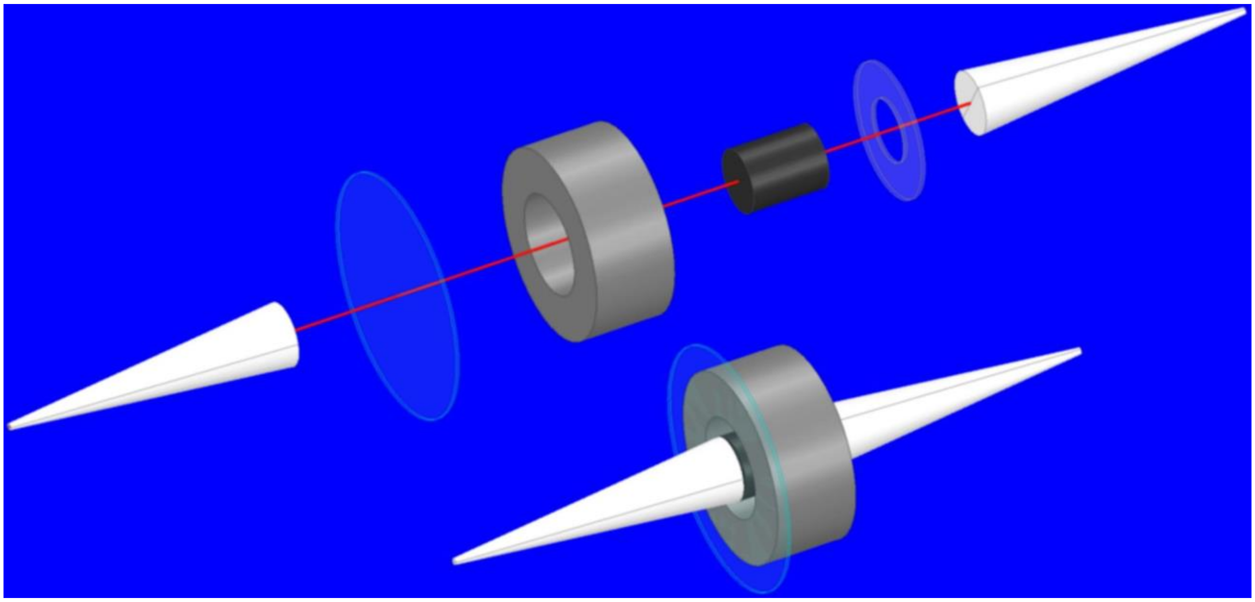
Our isolators employ a modern design yielding much lower insertion loss than most commercial products. They also work over much broader bandwidths in excess of standard waveguide bands. But there is another important difference that sets them apart from conventional products. Our isolators employ a diamond support disc that channels heat to the block and thus they can handle greater reverse power levels. To our knowledge no other commercial isolators offer this advantage.

At the heart of a Faraday rotation isolator are a pair of alumina cones and a cylindrical ferrite core. The cones are used to couple EM fields from the waveguides to the ferrite. The cones are bisected by a resistive layer along their central axis. In most commercial Faraday rotation isolators, the ferrite and cones are suspended by a pair of washer shaped supports as shown in the sketch below. The cone/ferrite assembly is inserted through the inner holes in the supports and then attached with a non-conductive epoxy. The support material is typically BoPET, polyimide, styrene, a resin or some other material with a low dielectric constant and low loss at millimeter wave frequencies (see Table at the bottom of this article). Materials with these characteristics are generally in the class of thermal insulators and thus the cones and ferrite are thermally isolated from the metal waveguide block.

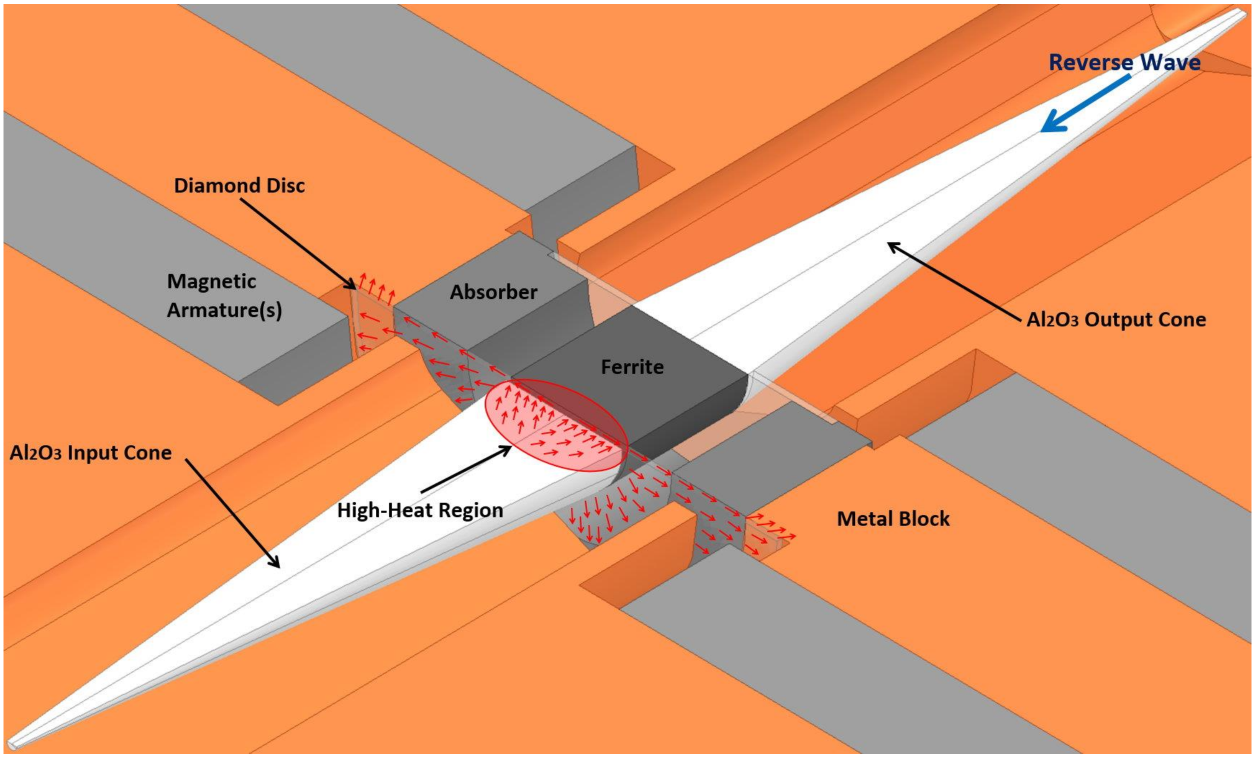


Power entering the output port of the isolator is absorbed in the resistive layer bisecting the input alumina cone. The absorbed power is converted to heat energy. Very little of this heat energy can be channeled away by thermal conduction through the supports, rather it must be dissipated through a radiative or convection process. The resistive layers are thus subject to high heat levels and even damage. Historically this was not an issue as there was very little power available at these frequencies. But as higher power sources are becoming available there is a renewed interest in the power ratings of these devices.

At Micro Harmonics we have replaced the input support washer with a uniform high-grade optical CVD diamond disc. Diamond is the ultimate thermal conductor approaching 2200 W/mK, more than five times higher than copper. The graphic below shows an exploded view of the isolator core to give a better view of the constituent parts (ferrite, cones, supports and absorber). The absorber inhibits exitation of higher order modes in the highly over-moded cavity. The diamond disc is sandwiched between the base of the input cone and the ferrite (left most support disc). The diamond disc is in intimate contact over the entire area of the cone base as shown in the graphic below. This is the optimal location since it is the region subject to the highest heat levels.



The assembled isolator core sits in a machined waveguide block as shown in the graphic below. The waveguide block and isolator core are split in half to allow a view of the interior. Magnetic armatures are also shown in the sketch. The armatures are used to focus the magnetic bias field from rare earth magnets onto the ferrite. The diamond disc is epoxied to the metal waveguide block over its periphery. The diamond is in intimate contact with the input cone and the metal waveguide block and thus it provides an excellent conduit to channel heat away from the resistive layer. The red arrows indicate the path of heat flow. Even at low reverse power levels, our isolators should consistently run cooler with reduced thermal stress on the resistive layer and epoxy joints.



Material	Description or Trade Name	Thermal Conductivity W/(m·K)	Dielectric Constant
Vacuum		0	1
Polystyrene		0.146	2.53
BoPET	Mylar®, Duralar®	0.155	3.3
Polyimide	Kapton®, Upilex-S®	0.2	3.5
PTFE	Teflon®	0.25	2.1
HDPE	High Density Polyethylene	0.5	2.4
Resin	Stycast 1266®	0.73	3
Borsilicate Glass	Pyrex®	1.1	4.6
Stainless Steel		15	
Alumina		30	9.8
Platinum		70	
Silicon		150	11.9
Aluminum		237	
Copper		400	
Diamond	High-Grade Polycrystalline CVD	1800	5.7
Diamond	Single Crystal CVD	2200	5.7
Material properties vary by manufacturer, frequency, temperature, etc.			