Electron spin resonance measurement of sapphire for KAGRA mirrors

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Gravitational waves predicted by general theory of relativity have not been detected yet. The KAGRA project (http://gwcenter.icrr.u-tokyo.ac.jp/en/), the Japanese gravitational wave detector project, is constructing a huge laser interferometer in Kamioka. Mono-crystal sapphire mirrors at cryogenic temperature will be used to reduce thermal noise; sapphire is chosen as its high mechanical Q value and high thermal conductivity at cryogenic temperature. Figure 1 is the photograph of the mono-crystal sapphire that will be used for the KAGRA mirror.

However, there are several problems; one of them is its optical absorption of laser light which might limit the achievable temperature of the cooled mirrors. In the previous reports, it was inferred that the absorption in sapphire originated from impurities (Fe\textsuperscript{3+}, Cr\textsuperscript{3+}, etc.) \cite{1}. Thus we are trying to identify impurities in sapphire by electron spin resonance (ESR) spectroscopy; we are using X-band microwave at room temperature, comparing peak positions and shapes of several samples. Figure 2 is an ESR peak signal measured with sapphire sample.


\begin{figure}[h]
\centering
\includegraphics[width=0.4\textwidth]{Fig1.png}
\caption{Mono-crystal sapphire mirror (diameter: 22 cm, thickness: 15 cm)}
\end{figure}

\begin{figure}[h]
\centering
\includegraphics[width=0.4\textwidth]{Fig2.png}
\caption{A peak of mono-crystal sapphire ESR (X-band, room temperature, power: 1mW)}
\end{figure}