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# Shallow Muonium radical in $\kappa$-Ga2O3 thin films.

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$Ga_2O_3$ is an emerging wide-gap semiconductor with a broad variety of applications, from transparent conduction to high voltage applications, therefore considered as a possible replacement for SiC. Its alpha polymorph, which can be grown in bulk crystalline form, is intensely investigated. An important technological development relies on the growth of thin film of the epsilon polymorph, since the small amount of required material allows for considerable cost reductions.

The role of hydrogen (H) in doping and passivation of vacancies, or dangling bonds, is very prominent in semiconductors, whereas spectroscopic technique capable of detecting H are not abundant. Muon spin spectroscopy is unique in its ability to provide insight on the behaviour of muons as light H isotopes in the extreme dilution case, which is impossible to access with 1H.

A Muonium (Mu) shallow donor center is reported [2],[3] in the $\beta$ polymorph, with a tiny hyperfine coupling of Bhf ~ 100 G and an activation energy for conversion to other muon species $E_a = 20(4)$ meV.
Here we present the result of a surface muon investigation of $\kappa$-$Ga_2O_3$ 30 micron-thick film grown on sapphire. The experiment required a special kapton degrader, obtained after careful tuning of its thickness, assisted by SRIM simulations. The measurements reveal a shallow Mu center with a similar tiny hyperfine coupling, but a significantly different activation energy (see figure)

[2] P. King et al., Appl. Phys. Lett. 96, 062110 (2010)

[3] Y.J. Celebi et al., Physica B 407, 2879 (2012)

Left: $\epsilon$-$Ga_2O_3$ time-dependent asymmetry; right: relaxation rate vs. temperature.

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