Acoustic Attenuation in Silica in the 100-250 GHz Range
Using Colored Picosecond Ultrasorons

Patrick EMERY1, Arnaud DEVOS2, Simon AYRINHAC3, Marie FORET3, Benoît RUFFLE3

1 ST Microelectronics, 851 rue Jean Monnet, 38920 CROLLES
2 Institut d’Electronique, de Microélectronique et de Nanotechnologies, Cité Scientifique - Avenue Poincaré, BP 60069 59652 Villeneuve d’Ascq Cedex
3 Laboratoire des Coïlôides, Verres et Nanomatériaux - UMR 5587 CNRS-UM2 MONTPELLIER

Abstract
We report on new measurements of the attenuation of longitudinal acoustic waves in vitreous silica using picosecond ultrasonics. We present a new way of using this ultrastuff technique which overcomes the difficulties encountered in the pioneering work of H. J. Maris.


Picosecond Ultrasorons

Ulfast technique based on a pump-probe scheme that enables non destructive mechanical measurements on μm to mm scale stacks

The given example illustrates the classical Picosecond ultrasonic technique to measure acoustic attenuation

Protocol description and Experimental results

Definition: The protocol enables attenuation measurements in thin films. We measure α, defined by:
Along the distance x, the acoustical energy is attenuated by a factor e^(-αx) at a given frequency.  

In some cases attenuation has to be measured in thin films deposited on a substrate with a low impedance contrast:

Classical technique: No impedance mismatch • 1 weak echo !!

Wavelength protocol:
2 frequencies come out • 40 GHz (travelling in Silica) • 240 GHz (travelling in Silicon)

The probed frequency depends on the material characteristics:

In thin films, high frequencies are needed to be sensitive to the attenuation effect on small distances - a few 100 nm

f_{40 GHz} = 40 GHz (negligible)

f_{240 GHz} = 240 GHz (measurable)

Results: measured energy attenuation at 236 GHz in v-SiO₂ (LPCVD sample)
α = 5.1 ± 0.9 .10⁻³ nm⁻¹ (corresponding to β=1.16±0.2.10⁻⁴ m⁻¹·THz⁻¹·strain field)

Wide band results: Using different probe wavelengths and substrates, the protocol can provide attenuation measurements in the hypersonic frequency range

Use of different substrates
Use of different wavelengths

Conclusion
• We measured LA attenuation for v-SiO₂ twice lower than that found in the pioneering work of H.J.Maris [Zhu et al PRB 44 4281 (1991)].
• Our results seems to be in line with a quadratic frequency dependence of attenuation up to 250 GHz.