# Response to "Comment on 'Visualizing coherent phonon propagation in the 100 GHz range: A broadband picosecond acoustic approach'" [Appl. Phys. Lett. 98, 246101 (2011)]

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The main point of the Comment raised by Courtens *et al.*[1] is to show that the frequency behavior of the acoustic attenuation $\Gamma(\nu)$ measured in our experiment[2] is compatible with a $\nu^2$ behavior and shows no crossover in the explored frequency range, once the effect of multiple reflections is taken into account. To this aim, the authors *assume a priori* a $\Gamma \propto \nu^2$ dependency, adjust it as the best interpolation to the experimental data and then apply a "backward" correction including the effects of multiple reflections according to the recipe given in their Ref. 3. In this way they verify *a posteriori* the existence of oscillations similar to those observed in our raw experimental data, as shown in Fig. 1 of the Comment. The aim of this Reply is twofold: (i) to benchmark the robustness of the procedure followed by Courtens *et al.* in their comment, applying an *identical* procedure but starting from a different interpolant. (ii) To apply a *direct* correction of our experimental data, accounting for multiple interference effects strictly following the recipe given by the commenting authors in Ref. 3. For both aims, as correctly recognized in Ref. 3, it is extremely important to accurately determine the samples thickness, as it critically affects the correction effect. Hence, we preliminary verified the accuracy of our samples thicknesses—measured by ellipsometry—given in our.[2] We did that using a procedure based on the direct determination of the transit time of the acoustic wave, similar to that described in Ref. 3. We found values which are in agreement with the ellipsometric values within 1%. To achieve aim (i), we have chosen a reasonably smooth $\Gamma(\nu)$ behavior discarding all the oscillations but showing a crossover at $\sim$170 GHz (green dotted line). Applying the "backward" correction with the very same procedure of the Comment,[1] we obtained the green dashed curve, which is in excellent agreement with our raw data (black curve). According to the same Comment philosophy, this indicates compatibility of our experimental data with a change in slope in $\Gamma(\nu)$. The opposite conclusion from the Comment is also reported in the same figure (thin dashed blue curve). For a fair comparison, we recalculated this latter using the same sample thicknesses accurately estimated by transit times. The overall agreement of this $\Gamma \propto \nu^2$ based line shape is comparable to that based on the nominal thicknesses shown in the Comment, significantly improved in the low frequency region and less good in the high frequency region. Comparing the residuals (insets) of the $\Gamma \propto \nu^2$ assumption (right panel, supported by the commenting authors) with those of the crossover assumption (left panel), it clearly emerges that the second should be preferred. The approach (i) proposed in Ref. 1 is, however, an indirect one based on a strong bias and on an *a posteriori* verification. The most direct way is obviously the procedure (ii), i.e., to correct for multiple reflections the raw acoustic amplitudes versus thickness curves. The method suggested in Ref. 3 seems to us very reasonable, and we strictly followed it. The result is the red continuous curve. The oscillation due to the unwanted interferometric effects are remarkably well accounted for. The genuine $\Gamma(\nu)$ extracted in this way still shows the change in slope envisaged in Ref. 2. Summing up, both the procedures (i) and (ii) do not rule out a kink in $\Gamma(\nu)$, as claimed in the Comment.

In agreement with commenting author's caveat, we stress once more that effect of the correction for multiple interferences heavily depends on the determination of sample

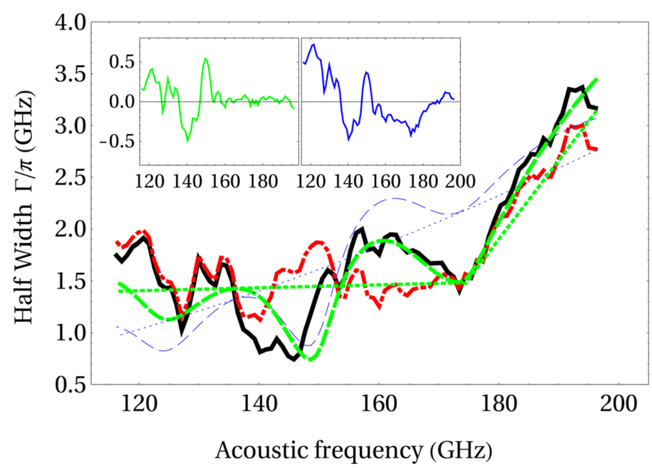


FIG. 1. (Color online) Main plot: raw acoustic attenuation as measured in Ref. 2 (black continuous curve). $\Gamma \propto \nu^2$ assumption from the Comment (thin dotted blue line) and corresponding uncorrected data (thin dashed blue curve). Crossover assumption and corresponding uncorrected data (green dotted line and green dashed curve, respectively). The dot-dashed red curve is the corrected $\Gamma(\nu)$ obtained from the raw data following the approach of the commenting authors given in Ref. 3. Insets show the residuals of the line shapes corresponding to the crossover (left) and $\Gamma \propto \nu^2$ (right) assumption.

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thicknesses, which should be carefully evaluated before making any strong statements. The wavelength dependence of these additional modulations, indeed, often shows very sharp features whose details (position and width) are heavily affected by the sample thickness. In this respect, our broadband approach turns out to be particularly helpful as it allows for a fine spectral sampling of these features. Finally, the conclusions drawn in Ref. 2 (as well as those of the present Reply) are valid for *thermally grown silicon oxide*, the sample under consideration in our study, and not necessarily for fused silica, as mentioned in the Comment.

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