

Improved Terahertz Output from Layered Organic Crystal Structures

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Abstract: We have improved the THz output and damage threshold of yellow organic THz generation crystals by fusing them to sapphire and using liquid crystals as index matching fluid to reduce reflective losses. © 2023 The Author(s)

1. Introduction

Yellow organic terahertz (THz) generation crystals such as BNA [1,2], MNA [3] and NMBA [4] have lower absorption cutoffs in the visible region than orange-red organic THz generators like DAST, DSTMS, and OH-1. This allows these crystals to be pumped with the output of a Ti:sapphire laser system. Although these crystals are more readily pumped with 800-nm light, they cannot be pumped at high fluences without melting due to low melting points and small amounts of two-photon absorption. Originally demonstrated for BNA [2], we have developed a way of improving the damage threshold by bonding these yellow crystals directly to sapphire plates (without any adhesive, the crystal is bonded directly to sapphire). The high thermal conductivity of the sapphire dissipates laser heat and enables the crystals to be pumped at higher fluences without melting. Pumping BNA, MNA, and NMBA crystals at higher fluences allows us to achieve greater THz electric fields. To increase THz output even further, we have developed a layered sandwich structure to reduce reflective losses that occur between the air and the THz generation crystal [5]. We demonstrate that a layer of the liquid crystal MBBA (N-(4-methoxybenzylidene)-4-butylaniline) can be used as an efficient THz index-matching fluid (with much lower THz absorption than regular liquids) between the sapphire-fused yellow crystal and 1.5 mm of Teflon. The introduction of this index-matching fluid reduces reflective losses as the IR light and THz light move through the materials.

2. Results

In our previous work, we have shown that fusing BNA crystals directly to sapphire plates increased their damage threshold by up to 10 mJ/cm² [2]. Bare BNA crystals can damage and melt at fluences as low as 4 mJ/cm², but sapphire-fused BNA will increase in THz output up until fluences of 14 mJ/cm². We fused yellow NLO crystals MNA and NMBA to sapphire, as well, improving their damage threshold and allowing us to make use of the full power of our Ti:sapphire laser system.

In a separate work, we showed that layering the NLO crystal DAST with THz index-matching fluid and materials such as glass and high-density polyethylene improved the generated THz intensity by about 50% [5]. This was the direct result of layering materials with similar refractive indices and THz index-matching fluid to decrease the amount of reflective loss at each surface.

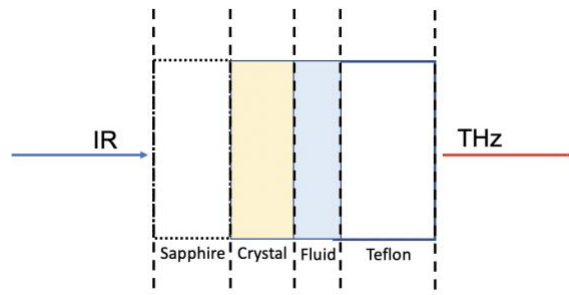


Figure 1. Diagram of a new sandwich structure. A layer of the liquid crystal MBBA (N-(4-methoxybenzylidene)-4-butylaniline) is sandwiched between the sapphire-fused crystal and Teflon. Reflective losses occur at each of the dashed lines.

In an effort to improve the damage threshold and the THz output of the yellow NLO crystals BNA, MNA and NMBA, we have layered each of these sapphire-fused NLO crystals with THz index-matching fluid, MBBA, and Teflon. Figure 1 shows a simple diagram of our updated layered structure. Even though the IR and THz light are still lost through reflection, this loss is reduced as the difference in refractive index between materials is reduced.

We measured the THz output of these NLO crystals when fused to sapphire, and then when in the sandwich structure. Figure 2a shows the THz generation spectra for BNA fused to sapphire (Bare Crystal), and this same sapphire-fused BNA in a sandwich structure (Structure) when pumped with the 1250 nm output from an OPA. We see that the Fourier amplitude is higher for the structure, than the sapphire-fused BNA over the 0.5 THz to 4.5 THz range. The inset shows the normalized THz intensity generated from the sandwich structure compared to the sapphire-fused crystal. We see that there is a 90 % improvement in the THz intensity when the BNA is in a sandwich structure. Similar plots are shown for NMBA in Figure 2b. The THz intensity improved by as much as 2× for NMBA.

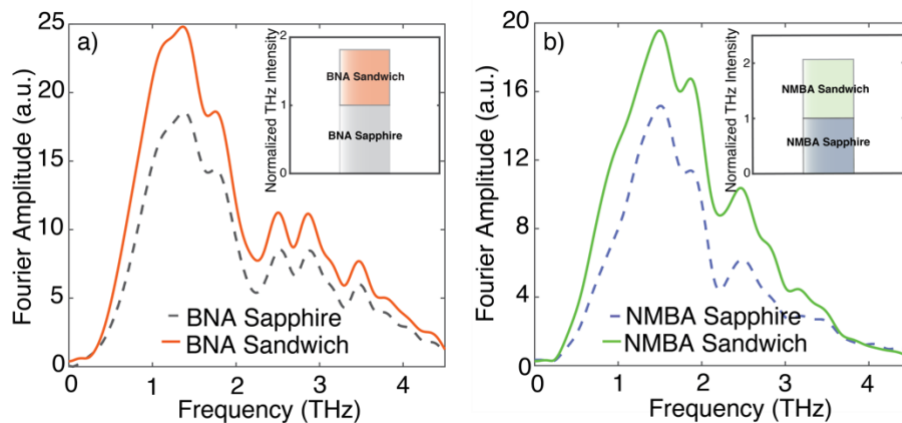


Figure 2. a) The THz spectra of a BNA crystal fused to sapphire (Bare Crystal) and the BNA-sapphire crystal in a layered structure (Structure). The normalized THz output intensities of the sandwich structure and crystal fused to sapphire. b) Plots showing the THz improvement of NMBA.

3. Summary

We have shown that we can improve the damage threshold and THz output of yellow organic THz crystals by bonding them to sapphire and layering them with THz index-matching fluid. This allows us to take advantage of the full power of Ti:sapphire laser systems while generating more THz. We will present on these improvements of damage threshold and THz output for the crystals BNA, MNA and NMBA.

4. References

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