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Low absorption ZnGeP₂ single crystals for tunable mid IR laser applications

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Mid infrared (3-12 μm) laser sources are essential for applications such as optical counter-measures (missile jamming) for military and civil aircraft security or remote chemical sensing. The principle of those sources is based on non linear effect: a short wavelength laser emission (1 or 2 μm) is converted into two long wavelength laser emissions, with complementary energies, inside a non linear crystal in an Optical Parametric Oscillator (OPO). The first critical parameter for our applications is the transparency of the crystals in the mid-IR range. However, classical non linear oxide crystals, which have a transparency limited to 4 μm due to multiphonon absorptions, are not appropriate. Thus, to go beyond this limit, non oxide materials are required like phosphides, selenides sulfides... Moreover, other important parameters are the crystal's resistance to high power and its non linear coefficients which have a direct influence on the energy conversion efficiency. ZnGeP₂ (ZGP) presents a good compromise between these properties and is a ternary compound of choice considering the applications cited above.

In this work, the high quality ZGP single crystal processing will be presented. It is divided into three main steps which will be precisely described: i) The chemical synthesis from high purity elements Zn, Ge and P which is carried out in a special designed furnace. The main difficulty of this step is to complete the chemical reaction while avoiding the reactor explosion which can occur because of the high vapor pressure of volatile compounds. ii) The crystal growth which is performed using the vertical Bridgman method. iii) Annealing post-treatments which are necessary to reduce the residual absorption around 2 μm . The absorption coefficient at this wavelength, which is the pumping wavelength for a ZGP based OPO, has to be as low as possible to increase the energy conversion efficiency. Crack free ZGP single crystals were grown following our process (Figure 1). Structural and optical quality characterizations will be presented and discussed. A very low absorption coefficient at 2 μm ($\sim 0.1 \text{ cm}^{-1}$) was obtained.

OPO tests as well as bigger crystal processing are currently in progress.



Figure 1: picture of a ZnGeP₂ crack free single crystal