Fe$^{2+}$:ZnSe and Fe$^{2+}$:ZnS passive Q-switches

Fe$^{2+}$:ZnSe and Fe$^{2+}$:ZnS saturable absorbers (SA) are ideal materials for passive Q-switches of solid-state lasers operating in the spectral range of 2.5-4.0 μm.

These lasers (e.g. 3.0 μm Er:YAG/YSAG/YLF) are used for pumping middle-infrared Optical Parametric Oscillators and for numerous medical and dental applications.

IPG’s fabrication process allows low cost mass production of a very large variety of diffusion-doped Fe$^{2+}$:ZnSe/Zns crystals with low losses, uniform distribution of iron, good reproducibility and reliability.

Absorption Spectra of Fe$^{2+}$:ZnS & Fe$^{2+}$:ZnSe Saturable Absorbers

Experimental Results for Transmission vs. Fluence in Fe:ZnSe (circles)

Numerical fit for

$\sigma_{\text{pia}} = 0.6 \times 10^{-18}$ cm$^2$ at 2.8 μm (solid line)
Fe\textsuperscript{2+}:ZnS and Fe\textsuperscript{2+}:ZnS
Passive Q-Switches

<table>
<thead>
<tr>
<th>Crystal</th>
<th>Peak coefficient absorption, cm\textsuperscript{-1}</th>
<th>Upper level lifetime at 300K, ( \mu \text{s} )</th>
<th>( \sigma_{gsa} ) at 2.8 ( \mu \text{m}, 10^{-20} \text{ cm}^2 )</th>
<th>( \sigma_{gsa}/\sigma_{esa} )</th>
<th>( \sigma_{gsa}/\sigma_{YSGG} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fe:ZnSe</td>
<td>1-20</td>
<td>0.37</td>
<td>90</td>
<td>0</td>
<td>30</td>
</tr>
<tr>
<td>Fe:ZnS</td>
<td>1-20</td>
<td>&lt;0.3</td>
<td>130</td>
<td>0</td>
<td>43</td>
</tr>
</tbody>
</table>

According to the criterion for Saturable Absorber Q-switching:

\[
\frac{\sigma_{Qgsa}}{\sigma_{YSGG}} \times \frac{A_{YSGG}}{A_Q} > 1
\]

Fe:ZnSe/S can be used as a saturable absorber Q-switch for the Cr:Er:YSGG laser without intracavity focusing.

Output energies of 15 and 85 mJ were achieved in single and multipulse modes of operation, respectively.

The combination of

- high values of saturation cross-section,
- small saturation energy with good opto-mechanical (damage threshold – 2 J/cm\textsuperscript{2}) and
- physical characteristics of ZnSe and ZnS hosts

makes Fe\textsuperscript{2+}:ZnSe/S crystals an ideal market for passive Q-switching of mid-infrared laser cavities.