

Crystal Systems, Inc.

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HEM SAPPHIRE GRADING SYSTEM

OVER 40 YEARS OF PRODUCING AND CHARACTERIZING SAPPHIRE CRYSTALS

Crystal Systems, Inc. has developed a precise method of grading HEM sapphire based on the homogeneity of refractive index and determination of inclusions/light scatter levels.

CRITICAL ASPECTS OF SAPPHIRE: PURITY, HOMOGENEITY & LIGHT SCATTER

PURITY LEVEL: All HEM grades of sapphire are > 99.996% purity level

HOMOGENEITY Transmitted wave front distortion values for different grades of HEM sapphire

<u>HOMOGENEITY GRADE</u>	<u>Homogeneity</u>	<u>Homogeneity, rms</u>	<u>PV (Wave)</u>
HEMEX	1.4×10^{-6} to 2.7×10^{-6}	1.8×10^{-7} to 3.3×10^{-7}	0.022 to 0.045
PREMIUM OPTICAL	2.8×10^{-6} to 4.2×10^{-6}	3.3×10^{-7} to 6.1×10^{-7}	0.045 to 0.063
STANDARD OPTICAL	4.2×10^{-6} to 6.5×10^{-6}	6.1×10^{-7} to 7.0×10^{-7}	0.063 to 0.100
MECHANICAL	> 6.5×10^{-6}	> 7.0×10^{-7}	> 0.100

LIGHT SCATTER/INCLUSIONS

<u>LIGHT SCATTER GRADE</u>	<u>Max Inclusion Size</u>	<u>Density</u>
HEMEX	No inclusions	no bubbles/inclusions
Class 2	< 0.009 mm	isolated bubbles, < 3 bubbles per cubic inch
Class 3	< 0.015 mm	random bubbles, < 8 per cubic inch
Class 4	< 0.020 mm	patches of bubbles, < 15 per cubic inch
Class 5	< 0.030 mm	concentrated areas of bubbles, < 30 per cubic inch

NOTE: bubble and inclusions above are maximum case scenarios; typically material is largely free of inclusions

Examples of material selection for customers

Customer X wants to procure sapphire material that will be fabricated and polished into an IR window with surface quality of 20-10 scratch dig per MIL –PRF13830B, with transmitted wave front error of ½ wave RMS @ 632 nm. Operating spectrum will be between 3 and 5 um, with average transmission > 85% over the range.

Material Specification: Customer X could use HEM standard optical quality material to obtain the ½ wave TWE RMS provided the polishing of the part was adequate to achieve the flatness and parallelism required. A scatter level of Class 3 would be sufficient to not disturb the surface quality requirements as well as prevent any significant scattering losses in the operating spectrum. All HEM sapphire is 99.996 % purity or better so transmission losses are avoided.

The Crystal Systems Staff will help you choose the most economical sapphire grade to satisfy your surface quality, transmitted wave front error and transmission requirements.