Transparent $CaLa_2S_4$ ceramics for IR applications

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Transparent ceramics are promising materials capable to offer equivalent optical transparency to glasses or single crystals with enhanced mechanical properties. Ceramics can be processed by powder sintering, on a large scale and low cost processes, compared to single crystal growth techniques. Transparent ceramics offer a number of different opportunities not only for military applications but also for civilian ones: medical imaging, night driving assistance, IR cameras, lasers, infrared missile domes, security windows/transparent armors. Chalcogenide ceramics are particularly suitable for IR applications due to their exceptional transparency up to LWIR.

This work focuses on synthesis and densification of a ternary sulfide $CaLa_2S_4$ with transmission range from visible to LWIR (0.5µm to 14µm) with superior mechanical properties compared to ZnS, the reference IR multispectral material. A higher hardness is particularly suited to withstand harsh environments (severe abrasion, wind sand, salt fog....) to which are subjected, for example, protective windows of multispectral optronic equipments for the Army or the Navy. A higher transparency in the infrared can significantly improve the performance of the infrared optical system and/or allow the use of uncooled detectors (operate beyond 12µm), resulting in a significant reduction in system cost.

$CaLa_2S_4$ powders are prepared by combustion method and post-heat treatment under H_2S [1,2]. Ceramics are obtained by hot pressing the powders to 99% densification.

	ZnS	ZnSe	MgF_2	CaF_2	$CaLa_2S_4$
Melting temperature (°C)	1020 (trans. wurtzite)	1100	1263	1418	1810
Transparency (µm)	0.4-12	0.5-14	0.11-9	0.13-12	0.5-14
Knoop hardness (Kg/mm²)	160-250	105	580	160	570
Strength (MPa)	70-100	50	100-150	55	106
Young's modulus (GPa)	74-88	70	142	76	96
Poisson's ratio	0.29-0.32	0.28	0.27	0.28	0.26

From Daniel C. Harris [3]

[1] Noha Hakmeh, Élaboration et caractérisation de luminophores et céramiques optiques IR à base d'(oxy)sulfures, Thèse de l'Université de Rennes 1, 2014.
[2] Christophe Chlique, Préparation et caractérisation de poudres et céramiques (oxy) sulfures pour applications en optique active et passive, Thèse de l'Université de Rennes 1, 2011.
[3] Daniel C. Harris, Materials for Infrared Windows and Domes : Properties and Performance, SPIE Optical Engineering Press, 1999 (ISBN: 0-8194-3482-5).