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Processability of LCD glass after hydrometallurgical process

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Introduction

Large quantities of LCD waste are generated worldwide, about 85 wt.% of it glass. Recovery of critical metals such as indium attracts growing interest, but the glass is overlooked and diverted to lower-value applications.

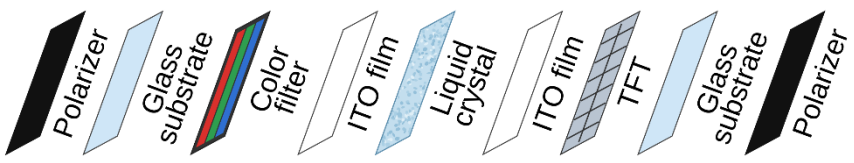


Figure 1: Exploded view of LCD screen.

Objective

Characterise the composition, structure and high-temperature processability of LCD glass recovered from different devices after hydrometallurgical indium extraction.

Methodology

End-of-life LCD screens → indium extraction → glass treatment

ICP-OES	Raman	^{27}Al MAS NMR	DSC	XRD
Concentric cylinder		Micro-penetration		

Future work: further multidimensional NMR and higher-field measurements will resolve overlapping environments and identify less abundant species.

Results and Discussion

Minor extraction of Al_2O_3 (2.5%) and alkaline-earth elements (0.7%) was detected during leaching. The recovered glass remains an aluminoborosilicate with a composition within the range reported in patents.

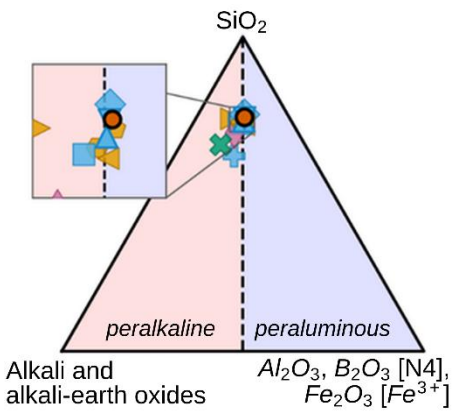


Figure 2: Re-melted glass composition vs. LCD glasses from literature and patents.

Deconvoluted Raman bands confirmed the polymerised nature of the glass (R = $(Q^4 + Q^3)/(Q^2 + Q^1)$ = 13.1; NBO/T = 0.55). ^{27}Al MAS NMR spectra show only $Al^{[4]}$.

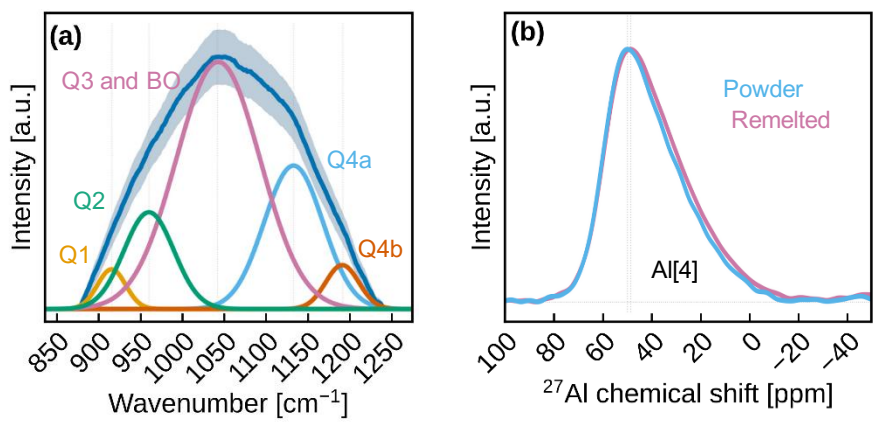


Figure 3: (a) Raman spectrum of the remelted glass deconvoluted into characteristic bands (b) ^{27}Al MAS NMR spectra of the powder and remelted glass.

Viscosity data were obtained in both super- and sub-liquidus regimes. DSC yielded $T_{g,onset}$ = 1012 ± 4 K and $T_{g,peak}$ = 1067 K, with no crystallisation events at conventional heating/cooling rates.

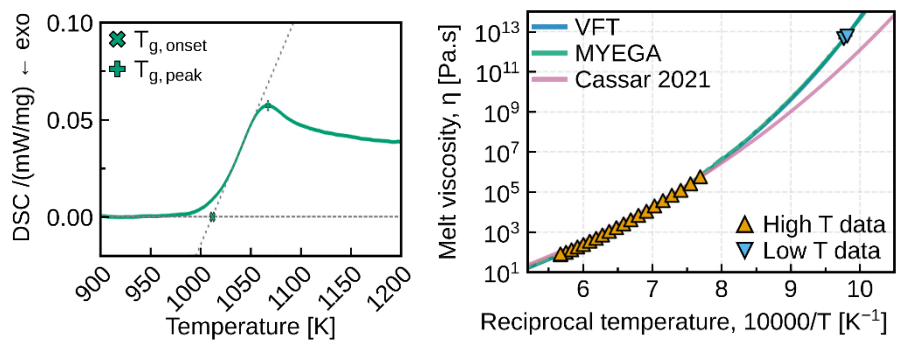


Figure 4: (a) DSC upscan of the remelted glass at 10 K min^{-1} (b) Viscosity vs. 10000/T: high-T (concentric cylinder) and low-T (micro-penetration) data, fitted with VFT, MYEGA and predicted by Cassar (2021).

High glass-forming ability was inferred with the JeZiCA formalism (JeZiCA = 1.01 × $10^{-1,}$ and high glass stability from heat treatments with subsequent XRD analyses above the T_g range.

Conclusions

The glass remained highly polymerised after indium extraction, with Al only four-coordinated. This structure is reflected in the high viscosity and T_g. Future work: multidimensional, higher-field NMR to resolve overlapping environments and less abundant species.

References and Acknowledgements

Cassar (2021) Acta Mater. 206, 116602; Ellison et al. (2017) US9604870B2; Gonçalves et al. (2026) Hydrometallurgy 242, 106691; Jiusti et al. (2020) J. Am. Ceram. Soc. 103, 921; Mauro et al. (2009) PNAS 106, 19780.

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