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PREPARATION OF INNOVATIVE GLASS-CERAMICS FOR ENERGY-STORAGE APPLICATIONS

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Abstract

This work investigates the synthesis and characterization of anorthite-based glass-ceramics ($CaAl_2Si_2O_8$) using local Algerian raw materials, namely DD2 kaolin from Djebel Debbagh (Guelma) and calcium carbonate from El Khroub (Constantine), with lithium nitrate ($LiNO_3$) as a sintering aid. Samples were sintered at 1100 °C with 0, 5, 10, and 15 wt.% $LiNO_3$ additions. The optimal composition at 10 wt.% $LiNO_3$ achieved the highest relative density (68.26%), the lowest porosity (39%), the best flexural strength (207.9 MPa), a Vickers hardness of 5.7 GPa, a low thermal expansion coefficient of 5.2×10^{-6} °C^{-1} at 1000°C, and the highest electrical conductivity (8.54×10^{-9} S/cm). XRD and FTIR analyses confirmed phase purity with anorthite as the sole crystalline phase. These properties make the synthesized ceramics promising candidates for energy applications, including photovoltaic substrates, solid oxide fuel cell components, and electrical insulators in power electronics.

Keywords: Anorthite, Lithium nitrate, Thermal expansion, Electrical conductivity, Energy applications.

Résumé

Ce travail porte sur la synthèse et la caractérisation de vitrocéramiques à base d'anorthite ($CaAl_2Si_2O_8$) en utilisant des matières premières locales algériennes, à savoir le kaolin DD2 de Djebel Debbagh (Guelma) et le carbonate de calcium d'El Khroub (Constantine), avec du nitrate de lithium ($LiNO_3$) comme adjuvant de frittage. Les échantillons ont été frittés à 1100 °C avec des teneurs en $LiNO_3$ de 0, 5, 10 et 15 % en masse. La composition optimale à 10 % de $LiNO_3$ a permis d'atteindre la densité relative la plus élevée (68,26%), la porosité minimale (39%), la meilleure résistance à la flexion (207,9 MPa), une dureté Vickers de 5,7 GPa, un faible coefficient de dilatation thermique de $5,2 \times 10^{-6}$ °C^{-1} à 1000°C, et la conductivité électrique la plus élevée ($8,54 \times 10^{-9}$ S/cm). Les analyses DRX et FTIR ont confirmé la pureté de phase, avec l'anorthite comme seule phase cristalline. Ces propriétés font des céramiques synthétisées des candidats prometteurs pour les applications énergétiques, notamment les substrats photovoltaïques, les composants de piles à combustible à oxyde solide et les isolants électriques en électronique de puissance.

Mots-clés : Anorthite, Nitrate de lithium, Dilatation thermique, Conductivité électrique, Applications énergétiques.

الملخص

يتناول هذا العمل تحضير وتوصيف سيراميك زجاجي قائم على الأنورثيت باستعمال مواد أولية محلية، وهي الكاولين المستخرج من جبل دباغ (قالمة) وكربونات الكالسيوم من الخروب (قسنطينة)، مع إضافة نترات الليثيوم كمساعد للتلبيد. تم تلبيد العينات عند درجة حرارة 1100°م مع إضافات من نترات الليثيوم بنسبة 0 و5 و10 و15 بالمئة وزناً.

حققت التركيبة المثلى المحتوية على 10 بالمئة وزنا من نترات الليثيوم على أعلى كثافة نسبية (68.26بالمئة)، وأقل مسامية (39بالمئة)، وأفضل مقاومة للإنحناء (207.9 ميغاباسكال)، وصلادة فيكرز بلغت 5.7 غيغاباسكال، ومعامل تمدد حراري منخفض قدره 5.2×10^{-6} °م$^{-1}$ عند 1000 °م، إضافة إلى أعلى ناقلية كهربائية (8.54×10^{-9} سيمنز/سم)

أكدت تحاليل حيود الأشعة السينية والتحليل الطيفي بالأشعة تحت الحمراء نقاوة الطور، حيث كان الأنورثيت هو الطور البلوري الوحيد. وتُظهر هذه الخصائص أن السيراميك المحضر يُعد مرشحاً واعداً لتطبيقات الطاقة، بما في ذلك ركائز الخلايا الكهروضوئية، ومكونات خلايا الوقود الصلب ذات الأكسيد والعوازل الكهربائية في إلكترونيات القدرة

الكلمات المفتاحية: الأنورثيت، نترات الليثيوم، التمدد الحراري، الناقلية الكهربائية، تطبيقات الطاقة