

**Microwave Dielectric Properties of Polybenzoxazine Based Composite
for Microwave Substrate Application**



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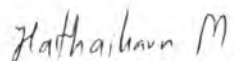
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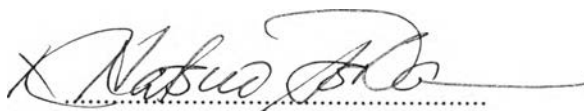


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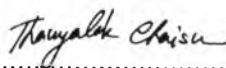
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ABSTRACT

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The composite of polybenzoxazine and barium strontium titanate (BST or $\text{Ba}_{0.3}\text{Sr}_{0.7}\text{TiO}_3$ with different BST loadings up to 80 wt. %) were synthesized and fabricated as a substrate. The effects of volume fraction of ceramic filler on the microstructure and microwave dielectric properties of the composite were studied for frequency and temperature dependence. A dielectric constant of 6.12 and loss tangent of 0.00065 at 1 GHz (room temperature) were obtained for aniline-based polybenzoxazine (PBA-a), which was higher than 4.49 and 0.00089 of the fluorine-based polybenzoxazine (PBA-f), respectively. Subsequently, PBA-a was used as a polymer matrix in the composite. The dielectric constant at 1 GHz could be increased from 6.12 up to 22 (without fillers), by adding BST 80 wt.% (48.8 vol.%). PBA/BST composites exhibited nearly zero temperature coefficient of dielectric constant in the range of $-50\text{ }^\circ\text{C}$ to $150\text{ }^\circ\text{C}$. The frequency dependence of the dielectric constant of the composite was found at 100 MHz – 1 GHz range. Additionally, the effects of surface modification on the dispersion of BST and microwave dielectric properties were studied using 3 chemical agents (3-aminopropyl-trimethoxysilane, phthalocyanine, and a benzoxazine monomer). The surface modification on BST by a silane compound agent enhanced the adhesion force between the matrix and filler resulted in the increase of the dielectric constant. Surface modification by phthalocyanine and the benzoxazine monomer could fabricate BST fillers dispersion better than the silane compound that leads to the lowering of loss tangent of the composite.

บทคัดย่อ

วศินี ทรัพย์มณีบุญกุล : การศึกษาสมบัติไมโครเวฟไดอิเล็กตริกของพอลิเบนซอกซาซีนคอมพอสิตสำหรับการใช้งานของไมโครเวฟซับสเตรท (Microwave Dielectric Properties of Polybenzoxazine Based Composite for Microwave Substrate Application) อ. ที่ปรึกษา: ผศ.ดร. หทัยกานต์ มนัสปิยะ และ ศ.ดร. ฮัทซีโอะ อิชิดะ 123 หน้า

วัสดุคอมพอสิตระหว่างพอลิเบนซอกซาซีนและผงแบเรียมสตรอนเทียมไดคานเนต (BST or $Ba_{0.3}Sr_{0.7}TiO_3$ ศึกษาที่สัดส่วน BST สูงสุดถึง 80 เปอร์เซ็นต์โดยน้ำหนัก) ถูกเตรียมขึ้นเพื่อใช้ในงานซับสเตรท โดยทำการศึกษาอิทธิพลของสัดส่วนผงเซรามิกต่อสมบัติไมโครเวฟไดอิเล็กตริกในสารคอมพอสิตพร้อมทั้งศึกษาการขึ้นกับความถี่และอุณหภูมิ จากการศึกษาพบว่าที่ 1 จิกะเฮิร์ต (อุณหภูมิห้อง) ค่าไดอิเล็กตริกและค่าลอสเทนเจนต์ของแอนนิลีนเบสพอลิเบนซอกซาซีนอยู่ที่ 6.12 และ 0.00065 ตามลำดับ ซึ่งสูงกว่า 4.49 และ 0.00089 ของฟลูออรีนเบสพอลิเบนซอกซาซีน ทำให้แอนนิลีนเบสพอลิเบนซอกซาซีนถูกใช้เป็นตัวพอลิเมอร์เมทริกซ์ในสารคอมพอสิต และพบว่าค่าไดอิเล็กตริกที่ 1 จิกะเฮิร์ตสามารถเพิ่มขึ้นจาก 6.12 (ไม่เติมสารเซรามิกในสารคอมพอสิต) เป็น 22 ได้โดยการใส่แบเรียมสตรอนเทียมไดคานเนต 80 เปอร์เซ็นต์โดยน้ำหนัก หรือ 48.8 เปอร์เซ็นต์โดยปริมาตร ทั้งนี้ยังพบว่าสารคอมพอสิตระหว่างพอลิเบนซอกซาซีนและแบเรียมสตรอนเทียมไดคานเนตแสดงสมบัติไดอิเล็กตริกที่ไม่เปลี่ยนแปลงตามอุณหภูมิในช่วง -50 ถึง 150 องศาเซลเซียส ในขณะที่พบการเปลี่ยนแปลงของสมบัติไดอิเล็กตริกในช่วงความถี่ 100 เมกะเฮิร์ต ถึง 1 จิกะเฮิร์ต ยิ่งไปกว่านั้นได้ทำการศึกษาถึงอิทธิพลของการปรับปรุงพื้นผิวผงแบเรียมสตรอนเทียมไดคานเนตต่อสมบัติการกระจายตัวของผงแบเรียมสตรอนเทียมไดคานเนตและสมบัติไมโครเวฟไดอิเล็กตริกในคอมพอสิตโดยใช้สาร 3 ชนิด ได้แก่ 3-อะมิโนโพรพิล-ไตรเมททอกซีไซเลน พทาโลไซยาไนด์และเบนซอกซาซีนมอนอเมอร์ โดยพบว่าการปรับปรุงพื้นผิวผงแบเรียมสตรอนเทียมไดคานเนตด้วยสารประกอบไซเลนช่วยเพิ่มแรงยึดติดระหว่างเนื้อพอลิเมอร์และเซรามิก ส่งผลให้สารคอมพอสิตมีค่าไดอิเล็กตริกที่เพิ่มขึ้น ในขณะที่การปรับปรุงพื้นผิวผงแบเรียมสตรอนเทียมไดคานเนตด้วยพทาโลไซยาไนด์และเบนซอกซาซีนมอนอเมอร์ช่วยทำให้แบเรียมสตรอนเทียมไดคานเนตกระจายตัวในคอมพอสิตได้ดีกว่าสารประกอบไซเลน ทำให้มีค่าลอสเทนเจนต์ที่ต่ำกว่า

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