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폴리타이포이드 기능경사를 이용한 Si3N4-Al2O3 계 이종 세라믹 간 접합을 위한 기능경사재료(FGM) 적층의 저감

(Reduction of functionally graded material (FGM) layers for joining dissimilar ceramics in Si3N4-Al2O3 system using polytypoid functional gradients)

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Reduction of functionally graded material (FGM) layers for joining dissimilar ceramics has been demonstrated in Si_3N_4-Al_2O_3 system using polytypoid functional gradients using three-dimensional analysis methods to check residual stress for FGM sample in this work. In the past, hot press sintering of multi-layered FGMs with 20 layers of thickness 500 um each has been fabricated successfully. The sample was hot pressed at 25 MPa, at 1700℃ and it was cooled at 2℃/min to minimize residual stress during processing. FEM(finite element method) program using Maximum principal stress theory was used to analyze the origin of the crack. As a result, we find that the experimental crack position matched the predicted crack position, obtained using simulation. Moreover, the fracture strength of each graded layer was calculated so that the position of low fracture strength across the graded layer was estimated to predict the position of the crack. Therefore, we were able to successfully estimate the crack position which matched the experimental results and calculate the fracture strength using FEM analysis. Such analyses are especially useful for graded FGM samples where the residual stresses are very difficult to measure experimentally.

Keywords: Si3N4-Al2O3 joining, FGM(functionally graded material), polytypoid, FEM(finite element method),

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Three-dimensional analysis of thermal stress and prediction of failure of Ni-Al2O3 Functionally Graded Material (FGM)

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Functionally Graded Materials is a technique where dissimilar materials can be joined by varying its composition continuously to minimize its residual stress. Recently, FGM is widely used as a boundary layer for multi-layer structure, binder, energy transformation materials, electronic materials, bio-materials, structure materials and etc. Therefore, FGM has been used in joining of various materials such as metal, ceramics, resin and etc.

In this work, we fabricated a crack-free joining of Ni and Al2O3 using functionally graded method. Appropriate proportions of Ni and Al2O3 were dispersed and mixed in ethanol solvent so that various compositions of graded layer were made. Each composition was stacked to make a green body. This green body was cold pressed, followed by CIP (Cold Isostatic Press) and sintered in pressureless sintering furnace at 1350℃ in Argon atmosphere. Finally, it was cooled at 2℃/min to minimize its residual stress during processing. Moreover, the particle size of Nickel and Al2O3 powders were varied to improve the density of green body so that the shrinkage can be minimized during sintering. Moreover, ANSYS simulation tool was used to calculate and to optimize the thickness and the number of layers for its crack-free joining. As a result, crack-free joining of Ni-Al2O3 sample was obtained, and hardness and modulus of each graded layer were measured using an indenter. These experimental values matched the calculated results, obtained by simulations and this analysis is proven to be useful where residual stresses are very difficult to measure experimentally.

Keywords: FGM(functionally graded material), Ni-Al2O3 joining, crack free, ANSYS simulation