# Microwave Sintering of W-Ir Matrix for Improved Emission Performance of Cathode

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**Abstract:** *Microstructural control of matrix is a critical way to improve the emission properties of cathode. In this work, microwave sintering strategy was developed to fabricate W-Ir alloy matrix with uniform grain size. The maximum of zero-field current density was measured to be 17.30 A/cm$^2$ at 1050 ℃b, which is superior to M type cathode coated with Ir and Ir- Re-W films.*

**Keywords:** microwave sintering; matrix; microstructure; porosity; emission performance.

## Introduction

MM-type cathode is an important emitter in high performance electronic devices due to its outstanding electron emission ability [1]. The cathode was fabricated by matrix sintering followed by barium aluminates impregnation process, and the microstructure of the metal matrix is critical to the emission properties of cathode. However, the conventional sintering usually suffers the abnormal grain growth due to a relatively long time heating, which affects its emission property.

Microwave sintering provides a possible route to form metal matrix with high porosity. Because the metal powders absorb microwave energy to heat the sample from the interior, the uniform microstructure is preferred to be obtained due to the active sintering process [2]. In this work, microwave sintering was applied to fabricate W-Ir matrix to improve its microstructure, and results illustrate that uniform matrix exhibits a current density of 10.18 A/cm$^2$ at 1000℃b (brightness temperature).

## Experimental

W powders (2.3 µm) and Ir powders (5 µm) were firstly mechanically mixed and pressed to green pellets with W-20wt.%Ir. As formed compacts were then microwave sintered at different temperature for 10 min. Subsequently, matrix was impregnated with 4:1:1 barium calcium aluminates and annealed at 1200 ℃ after removing excess impregnant residues. Phase and microstructure were detected by X-ray diffraction (XRD) (D/MAX-3C) and Scanning Electron Microscopy (SEM, Hitachi S-3500N). Emission performance of cathodes were measured in a closely spaced diode configuration.

## Results and discussion

The phase and microstructure of matrix obtained by microwave sintering were investigated and shown in Fig. 1. From the SEM images of matrices sintered at different temperatures, it was observed that temperature has a great influence on the microstructure of obtained compacts. At low sintering temperature of 1470 ℃ (Fig. 1a), the grains with average size of 2.5 µm was obtained, and partly formed metal skeleton. The matrix has a high porosity of 37.48% and poor binding strength between the grains.

With the sintering temperature increased to 1500 ℃, the

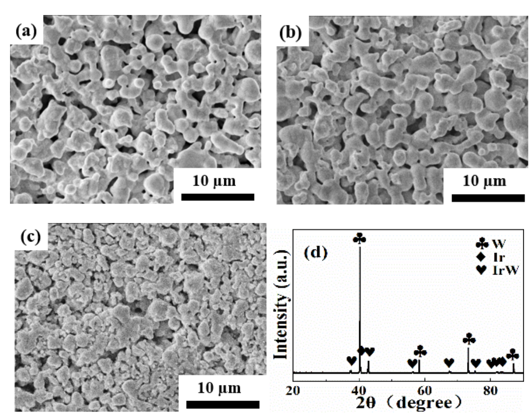


**Fig. 1 SEM images of matrix sintered at different temperature: (a) 1470 ℃, (b) 1500 ℃ and (c) 1530 ℃. (d) XRD pattern of matrix sintered at 1500 ℃.**

grain size grows up to around 3 µm and exhibits a fully inter-connected metal skeleton, as shown in Fig. 1b. Meanwhile, a high bulk porosity of 28.48% was obtained. With further increasing temperature to 1530 ℃ (Fig. 1c), unusual coarsening of the grains was existed in the obtained compact and the porosity was down to 17.5% due to the overgrowth of the grains, which is negative to the impregnation of barium aluminates. Fig. 1d presented the typical XRD pattern of compact sintered at 1500 ℃, and the result indicates that IrW alloy has formed together with the existence of W and Ir.

Fig. 2 presents the microstructures and phase composition of the matrix (sintered at 1500 ℃) after impregnation of barium aluminates. From the surface image of compact in Fig. 2a, it was observed that the impregnants have been uniformly embedded into the pores of the metal matrix, and the high weight increase of 10.41% was obtained, which indicates the good introduction of impregnant. In addition, $Ba_2CaWO_6$ and $Ba_2CaIrO_6$ phases were detected by XRD analyses as shown in Fig. 2b, which indicates the reaction was occurred between the matrix and active substances during the annealing process. But needs further study.

The emission properties of W-Ir cathode measured in the testing temperature range of 1000-1075 ℃ were shown in Fig. 3. It was observed that the zero-field current density exhibits a rising trend as the test temperature increased. The current densities were determined to be 10.18 A/cm$^2$ at 1000 ℃b and 17.30 A/cm$^2$ at 1050 ℃b, superior to the M type cathodes coated with Ir and Ir-Re-W films [3, 4]. These results indicates the greatly improved emission performance of W-Ir MM-type cathodes with matrix fabricated by microwave sintering.

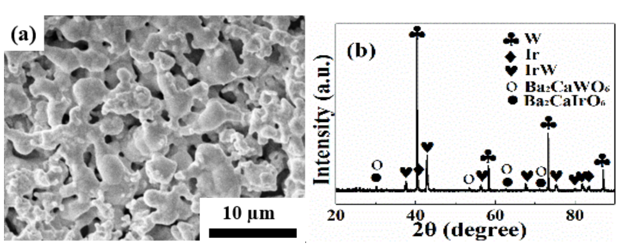


**Fig. 2 (a) Microstructure and (b) XRD pattern of the matrix after impregnation of barium aluminates.**

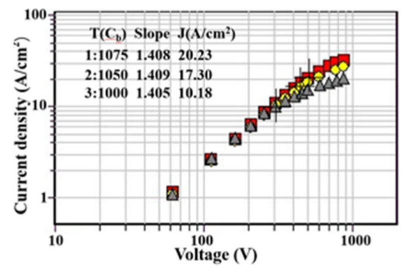


**Fig. 3 Pulse *I-V* characteristics of W-Ir cathode.**

## Conclusion

In this work, microwave sintering was applied to fabricate W-Ir alloys skeleton with uniform grain size. The cathode exhibits an emission performance with zero-field current density of 20.23 A/cm$^2$ at 1075 ℃b, which highlight the advantage of as proposed strategy to fabricate cathode with excellent performance.

## Acknowledgments

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