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## **Operation pressure and lifetime improvement of bialkali photocathodes via graphene protection**

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Protection of free-electron sources has been technically challenging due to lack of materials that transmit electrons while preventing corrosive gas molecules. Two-dimensional (2D) materials uniquely possess both of required properties. Here, we report three orders of magnitude increase in operation pressure and factor of two to four enhancement in the lifetime of high quantum efficiency (QE) bialkali photocathodes (cesium potassium antimonide (CsK2Sb)) by protecting them with graphene. The photoelectrons were extracted through the graphene protection layer in a reflection mode, and we achieved QE of ~0.14 % at ~3.4 eV, 1/e lifetime of 188 hours during operation, and no decrease of QE during operation at pressure of as high as ~1×10-3 Pa. In comparison, the QE decreased drastically at 10-6 Pa for bare, non-protected CsK2Sb photocathodes and their 1/e lifetime during operation was ~48 hours. We attributed the improvements to the gas impermeability and photoelectron transparency of graphene.

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## Footnotes

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Yes

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