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Ullom et al.

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(54) **X-RAY SPECTROMETER**

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See application file for complete search history.

(56) **References Cited**
U.S. PATENT DOCUMENTS
5,777,336 A * 7/1998 Silver G01N 23/207
250/336.2
5,880,467 A * 3/1999 Martinis G21K 1/06
250/310
(Continued)

OTHER PUBLICATIONS
English translation of JP application JP 2009 270465 (Published as JP 2011112561 A).
(Continued)

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(57) **ABSTRACT**
An x-ray spectrometer includes: an x-ray plasma source that produces first x-rays; an x-ray optic in optical communication with the x-ray plasma source and that: receives the first x-rays from the x-ray plasma source; focuses the first x-rays to produce second x-rays; and communicates the second x-rays to a sample that produces product x-rays in response to receipt of the second x-rays and second light; and a microcalorimeter array detector in optical communication
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