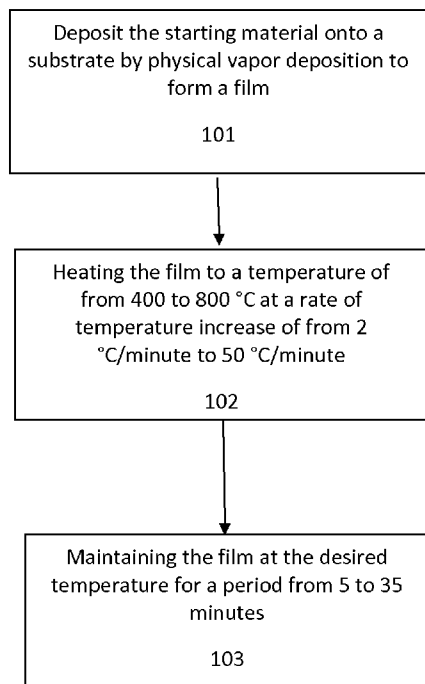




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[Continued on next page]

(54) Title: GRAIN SIZE TUNING FOR RADIATION RESISTANCE



(57) Abstract: A process for producing a radiation resistant nanocrystalline material having a polycrystalline microstructure from a starting material selected from metals and metal alloys. The process including depositing the starting material by physical vapor deposition onto a substrate that is maintained at a substrate temperature from about room temperature to about 850 °C to produce the nanocrystalline material. The process may also include heating the nanocrystalline material to a temperature of from about 450 °C to about 800 °C at a rate of temperature increase of from about 2 °C/minute to about 30 °C/minute; and maintaining the nanocrystalline material at the temperature of from about 450 °C to about 800 °C for a period from about 5 minutes to about 35 minutes. The nanocrystalline materials produced by the above process are also described. The nanocrystalline materials produced by the process are resistant to radiation damage.





SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ,  
GW, KM, ML, MR, NE, SN, TD, TG).

— before the expiration of the time limit for amending the  
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— of inventorship (Rule 4.17(iv))

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**A. CLASSIFICATION OF SUBJECT MATTER****H01L 21/203(2006.01)i**

According to International Patent Classification (IPC) or to both national classification and IPC

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)

H01L 21/203; H01L 21/28; H01L 29/94; C09K 11/59; B32B 9/04; B29D 22/00; B32B 33/00; H01L 29/788; C09D 1/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

eKOMPASS(KIPO internal) &amp; Keywords:nanocrystal, PVD, temperature, carbide, ceramic, metal, oxide, silicon

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2008-0135914 A1 (NETY M. KRISHNA et al.) 12 June 2008 See abstract, paragraphs [0024]-[0047] and figures 2A-4.	1-5, 10, 12-15, 17-18
Y		6-9, 11, 16
Y	US 2013-0122317 A1 (NARAYANA SASTRY CHERUVU et al.) 16 May 2013 See abstract, paragraphs [0035]-[0043] and figure 4.	6-9, 16
Y	US 2013-0059121 A1 (THE GOVERNORS OF THE UNIVERSITY OF ALBERTA) 07 March 2013 See abstract, paragraph [0032] and figure 1.	11
A	US 2008-0035021 A1 (SANKAR SAMBASIVAN et al.) 14 February 2008 See abstract, paragraphs [0059]-[0072] and figures 1-4.	1-18
A	US 2006-0017081 A1 (JIJUN SUN et al.) 26 January 2006 See abstract, paragraphs [0012]-[0032] and figures 1-3.	1-18

 Further documents are listed in the continuation of Box C. See patent family annex.

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"P" document published prior to the international filing date but later than the priority date claimed

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"&amp;" document member of the same patent family

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## INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2014/071932

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2008-0135914 A1	12/06/2008	None	
US 2013-0122317 A1	16/05/2013	None	
US 2013-0059121 A1	07/03/2013	CA 2609537 A1 CA 2609537 C EP 1883949 A1 EP 1883949 A4 JP 2008-545826 A JP 5424638 B2 KR 10-1331435 B1 KR 10-2008-0042047 A US 2009-0117392 A1 US 8323731 B2 WO 2006-125313 A1	30/11/2006 30/07/2013 06/02/2008 07/03/2012 18/12/2008 26/02/2014 21/11/2013 14/05/2008 07/05/2009 04/12/2012 30/11/2006
US 2008-0035021 A1	14/02/2008	AU 2006-261669 A1 AU 2006-261669 B2 BR PI0612496 A2 CA 2613596 A1 CN 101242948 A CN 101242948 B EP 1904290 A2 EP 1904290 A4 JP 2008-546633 A JP 5349043 B2 US 7833342 B2 WO 2007-002744 A2 WO 2007-002744 A3	04/01/2007 07/07/2011 23/11/2010 04/01/2007 13/08/2008 13/06/2012 02/04/2008 18/12/2013 25/12/2008 20/11/2013 16/11/2010 04/01/2007 20/03/2008
US 2006-0017081 A1	26/01/2006	CN 100533763 C CN 1985377 A JP 2008-507854 A KR 10-1149393 B1 KR 10-2007-0035588 A TW I417878 B US 7098495 B2 WO 2006-023018 A2 WO 2006-023018 A3	26/08/2009 20/06/2007 13/03/2008 25/05/2012 30/03/2007 01/12/2013 29/08/2006 02/03/2006 22/06/2006