



US007074498B2

(12) **United States Patent**
Tavkhelidze et al.

(10) **Patent No.:** **US 7,074,498 B2**
(45) **Date of Patent:** **Jul. 11, 2006**

(54) **INFLUENCE OF SURFACE GEOMETRY ON METAL PROPERTIES**

(56) **References Cited**

(75) Inventors: **Avto Tavkhelidze**, Tbilisi (GE); **Stuart Harbron**, Berkhamstead (GB)

U.S. PATENT DOCUMENTS

(73) Assignee: **Borealis Technical Limited** (GI)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

- 3,740,592 A 6/1973 Engdahl et al.
- 4,011,582 A 3/1977 Cline et al.
- 4,039,352 A 8/1977 Marinescu
- 4,063,965 A 12/1977 Cline et al.
- 4,686,162 A 8/1987 Stangl et al.
- 5,023,671 A 6/1991 DiVincenzo et al.
- 5,068,535 A 11/1991 Rabalais
- 5,119,151 A 6/1992 Onda
- 5,229,320 A 7/1993 Ugajin
- 5,233,205 A 8/1993 Usagawa et al.
- 5,247,223 A 9/1993 Mori et al.
- 5,332,952 A 7/1994 Ugajin et al.

(21) Appl. No.: **10/508,914**

(22) PCT Filed: **Mar. 24, 2003**

(86) PCT No.: **PCT/US03/08907**

§ 371 (c)(1),
(2), (4) Date: **Sep. 22, 2004**

(Continued)

(87) PCT Pub. No.: **WO03/083177**

PCT Pub. Date: **Oct. 9, 2003**

FOREIGN PATENT DOCUMENTS

JP 4080964 A 3/1992

(Continued)

(65) **Prior Publication Data**

US 2005/0147841 A1 Jul. 7, 2005

OTHER PUBLICATIONS

Chou et al., *Imprint Lithography with 25 Nanometer Resolution*, Science, Apr. 5, 1996, pp. 85-87, vol. 272.

Related U.S. Application Data

Primary Examiner—Evan Pert

(60) Provisional application No. 60/373,508, filed on Apr. 17, 2002, provisional application No. 60/366,564, filed on Mar. 22, 2002, provisional application No. 60/366,563, filed on Mar. 22, 2002.

(57) **ABSTRACT**

(51) **Int. Cl.**
C23F 4/00 (2006.01)
H01R 3/00 (2006.01)
H01L 21/00 (2006.01)

The influence of surface geometry on metal properties is studied within the limit of the quantum theory of free electrons. It is shown that a metal surface can be modified with patterned indents to increase the Fermi energy level inside the metal, leading to decrease in electron work function. This effect would exist in any quantum system comprising fermions inside a potential energy box. Also disclosed is a method for making nanostructured surfaces having perpendicular features with sharp edges.

(52) **U.S. Cl.** **428/687**; 29/825; 438/20

(58) **Field of Classification Search** 438/20;
428/687

See application file for complete search history.

25 Claims, 8 Drawing Sheets

