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PATENT ASSIGNMENT

Electronic Version v1.1

Stylesheet Version v1.1

04/01/2010
501136589

SUBMISSION TYPE:	CORRECTIVE ASSIGNMENT										
NATURE OF CONVEYANCE:	Corrective Assignment to correct the execution date for inventor Liming Chen previously recorded on Reel 024042 Frame 0715. Assignor(s) hereby confirms the execution date for inventor Liming Chen, which was incorrectly listed as "08/26 2006" should be "08/28/2006"..										
CONVEYING PARTY DATA											
<table border="1"><thead><tr><th>Name</th><th>Execution Date</th></tr></thead><tbody><tr><td>Valerian Pershin</td><td>08/28/2006</td></tr><tr><td>Javad Mostaghimi</td><td>08/28/2006</td></tr><tr><td>Liming Chen</td><td>08/28/2006</td></tr></tbody></table>		Name	Execution Date	Valerian Pershin	08/28/2006	Javad Mostaghimi	08/28/2006	Liming Chen	08/28/2006		
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Javad Mostaghimi	08/28/2006										
Liming Chen	08/28/2006										
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<table border="1"><tr><td>Name:</td><td>The Governing Council of the University of Toronto</td></tr><tr><td>Street Address:</td><td>27 King's College Circle</td></tr><tr><td>City:</td><td>Toronto, Ontario</td></tr><tr><td>State/Country:</td><td>CANADA</td></tr><tr><td>Postal Code:</td><td>M5S 1A1</td></tr></table>		Name:	The Governing Council of the University of Toronto	Street Address:	27 King's College Circle	City:	Toronto, Ontario	State/Country:	CANADA	Postal Code:	M5S 1A1
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Application Number:	12227439										
CORRESPONDENCE DATA											
Fax Number: (703)739-9889 <i>Correspondence will be sent via US Mail when the fax attempt is unsuccessful.</i>											
Phone: 703-739-9888											
Email: dowell@dowellpc.com											
Correspondent Name: DOWELL & DOWELL, P.C.											
Address Line 1: 103 Oronoco Street											
Address Line 2: Suite 220											
Address Line 4: Alexandria, VIRGINIA 22314											
ATTORNEY DOCKET NUMBER:	16648NP										
NAME OF SUBMITTER:	Alyssa Ann Finamore										

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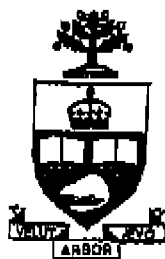
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SUBMISSION TYPE:	NEW ASSIGNMENT										
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Fax Number: (703)739-8888 <i>Correspondence will be sent via US Mail when the fax attempt is unsuccessful.</i>											
Phone: 703-739-8888											
Email: dowell@dowellpc.com											
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Address Line 1: 103 Oronoco Street											
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Address Line 4: Alexandria, VIRGINIA 22314											
ATTORNEY DOCKET NUMBER:	18848NP										
NAME OF SUBMITTER:	Alyssa Ann Finamore										
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University of Toronto

OFFICE OF THE VICE-PRESIDENT, RESEARCH AND ASSOCIATE PROVOST

ASSIGNMENT OF RIGHTS TO THE UNIVERSITY OF TORONTO BY THE INVENTOR

In consideration of the sum of two dollars (\$2.00) and other good and valuable consideration, the receipt and sufficiency of which are hereby acknowledged, Valerian Pershin, Javad Mostaghimi, Liming Chen, and their heirs, executors, administrators and assigns (collectively the "Assignor") hereby sell, assign and transfer to The Governing Council of the University of Toronto, its successors and assigns (collectively the "Assignee") all right, title and interest which the Assignor now has or may hereafter have in an invention described as

DC Plasma Torch with Constantly Restored Cathode from Carbon Containing Gas Mixtures

in Appendix A annexed hereto, (the "Invention")

including, without limitation, the right to apply for patents in Canada, the United States of America and any other country, the right to receive any letters patent that may be issued from any such applications, the right to have any letters patent that have been granted transferred into the name of the Assignee, and the right to sell, license or assign the Invention or the rights thereto.

The Assignor hereby releases the Assignee from any and all manner of claims and demands which the Assignor may now have or may in future have in respect of the Invention or in connection with the patenting, sale or licensing thereof.

Executed at Toronto, Ontario this 28 day of August, 2006.

Witness

[Signature]
[Signature]
[Signature]

Inventors

[Signature]
Valerian Pershin
[Signature]
Javad Mostaghimi
[Signature]
Liming Chen

Simcoe Hall, Room 1336, 27 King's College Circle, Toronto ON, M5S 1A1
☎ 416.978.7833 ☎ 416.978.5821 ✉ paul.mcarthur@utoronto.ca

Appendix A

**UNIVERSITY OF TORONTO INVENTIONS POLICY
CONFIDENTIAL INTELLECTUAL PROPERTY DISCLOSURE**

Office of the Vice-President - Research and International Relations
37 King's College Circle, Room 133-9
Tel: (416) 978-7833 Fax: (416) 978-5821 email: paul.mcarthur@utoronto.ca

1. Title: **DC PLASMA TORCH WITH CONSTANTLY RESTORED CATHODE FROM CARBON CONTAINING GAS MIXTURES**

2. a) University of Toronto Inventors/Major Contributors:

SURNAME, GIVEN NAMES	UNIVERSITY PERSONNEL NO.	DEPARTMENT (LIST ANY CROSS APPOINTMENTS OR AFFILIATED INSTITUTIONS)	AFFILIATION WITH UNIVERSITY (i.e. faculty, staff, student, post-doc, student, etc., state, etc.)	CURRENT ADDRESS, PHONE, FAX, EMAIL
Parahin Valerian	108378	Mechanical and Industrial Eng.	Sr. research associate	48 Minerva Rd, East Mississauga, Ontario Canada, L6G 2E4 416-978-4297 parahin@mie.utoronto.ca
Montaghiral Javed	33414	Mechanical and Industrial Eng.	Professor	1858 Kentshaster Place Mississauga, Ontario Canada, L5N 7S7 416-978-5804 montag@mie.utoronto.ca
Chen Liming	98337700	Mechanical and Industrial Eng.	Ph.D. student	36 Charles Street West, Apartment 1112, Toronto, ON, Canada, M5Y 1R6 416-948-8470 liming@mie.utoronto.ca

2. b) External Inventors/Major Contributors:
(Please provide names and affiliations of non-University of Toronto individuals who have made a creative contribution to this Intellectual Property, i.e. sponsor employees, academic collaborators, etc.)

3. Description:

(Please highlight the novelty or patentable aspects of this Intellectual Property; attach a separate sheet if necessary)

A New type of DC plasma torch which has long cathode lifetime and improved thermal efficiency has been developed. One of the essential features of this torch is a graphite cathode. Cathode erosion caused by high heat fluxes is constantly restored by carbon ions flowing from the plasma and precipitating on the

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cathode surface. The process of restoration takes place as a result of arc operating with carbon containing gas mixtures which provides compensation for the cathode erosion.

The gas mixture could be in the form of mixtures of any hydrocarbon (natural gas, methane, propane, etc.) and carbon dioxide. Because of the high plasma temperature, hydrocarbons completely dissociate and ionise into free carbon and hydrogen atoms and ions. When appropriate conditions are established, carbon ions from the gas phase move to the cathode surface, where dynamic equilibrium between carbon evaporation and precipitation takes place. This process compensates cathode erosion and ensures a virtually unlimited operating life.

Other important aspect of this design is the presence of hydrogen in the gas phase resulting in higher thermal efficiency of the torch. Carbon dioxide, as a molecular gas also increases the enthalpy of the jet and, because of its high molecular mass, at the same time stabilizes the arc column. The proposed plasma torch, contrary to the commercial torches in the market, does not need argon as plasma gas or tungsten for cathode material. The lower cost of carbon dioxide (~1/2 price of argon) as well as the higher thermal efficiency of the torch is attractive economic features of this design.

There is considerable flexibility in operating the new plasma torch. This is provided by the ability to operate the torch to operate with a wide range of hydrocarbons and carbon dioxide mixtures. This is attractive to the thermal spray coating industry where the proposed torch may operate under condition where one can vary the reduction-oxidation potential of the plasma jet. This is impossible to achieve with the commercial torches operated with argon, argon-hydrogen, or argon-helium gas mixtures. Typical arc voltage for the new torch is 110-180V. In comparison, the commercial torches operated with argon-hydrogen mixture, have an arc voltage of 45-60 V. Thus, the new torch generates the same power but at much lower arc current. This reduces the thermal load on the electrodes extending their service life considerably.

Compared to the conventional torches, measured thermal efficiency of the new torch is higher by 20-40%.

In addition to the thermal spray coating industry, the combined high thermal efficiency and long electrode life of the new torch makes it a promising tool for hazardous waste treatment.

For more information on University of Toronto intellectual property policies, please call 416-978-7833 or access <http://www.library.utoronto.ca/techtran/>.
For information on commercialization, patentability, protection costs, and time constraints when publication is contemplated, please call the Innovations Foundation at 416-578-5117.

Confidential Invention Disclosure

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4. How was the work leading to this Intellectual Property funded? *E.g. salaries, equipment used, supplies etc.*

SPONSOR	GRANT OR CONTRACT FUND #	INTELLECTUAL PROPERTY TERMS & CONDITIONS
Canada Foundation for Innovation	Operating Grant 462026	
Ontario Innovation Trust	Operating Grant 463048	

5. Where did the work leading to this Intellectual Property take place?
Work has been conducted at Centre for Advanced Coating Technologies (CACT), MIE
Department, University of Toronto

6. Is this Intellectual Property subject to any software licence, material transfer, confidentiality, non-
disclosure, collaboration or other agreement, written or oral, not referenced in Section 4?
 X NO YES (if "yes", please provide details)

7. What are the potential applications and/or sources of revenue from this Intellectual Property?
Two major areas of application are: a) thermal spray coating; and, b) hazardous waste treatment.
Both processes will benefit from the higher energy output due to the use of high enthalpy gases
for plasma generation. Longer life of electrodes will reduce downtime. It also decrease fluctuation
in process parameters because of low electrodes erosion. Lower cost of carbon dioxide (1/2
price of argon) and higher power deposition rate makes the operation of the torch economically
attractive.

8. Warranty:

I/We, the Inventors/Contributors listed in Section 2(a), have read, understood and agree to all of the preceding and
declare that all of the information provided in this disclosure is complete and correct. To the best of our knowledge, all
persons who might legally make an ownership claim in this Intellectual Property are identified in Section 2(a) and 2(b).

For more information on University of Toronto Intellectual property policies, please call 416-978-7833 or access
<http://www.library.utoronto.ca/techtrans/>.
For information on commercialization processes and procedures please call the Innovations Foundation at 416-978-6117.

BS

Pershin Dec 8.05
Signature _____ Date _____
Typed Name: V. Pershin

Javad Mosteghani
Signature _____ Date _____
Typed Name: J. Mosteghani

Lining Chen Dec 8/2013
Signature _____ Date _____
Typed Name: L. Chen

Signature _____ Date _____
Typed Name: _____

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