Background Information on Material Tests

Tests performed for Dane Taylor Technologies concerning a respirator filter system

Jurg A. Schutz
27 July 2012

Commercial-in-confidence

Sustainable High Performance Materials Research Theme, CSIRO Future Manufacturing Flagship

Contents

Figures

Tables

Background Information on Material Tests

CSIRO was approached by Mike Taylor, Director of Dane Taylor Technologies Pty Limited, to provide supplementary and explanatory information on tests performed on two filter media supplied by Dane Taylor Technologies to more fully describe the test methodology employed.

The two media with identifiers MTR05 and MTR06 were structured as follows:

Table 1: The structure of filter media subjected to material testing (see Appendix B).

Medium	**~~MTR05~~**	**Share**	**MTR06**	**Share**	**Basis Weight**
Front	~~Fire-resistant cotton~~	~~25%~~	Fire-resistant cotton	21%	250 gsm
2	~~Alpaca~~	~~28%~~	Alpaca	25%	290 gsm
3	[redacted]	~~19%~~	[redacted]	16%	185 gsm
4	-		[redacted]	13%	155 gsm
Back	~~Alpaca~~	~~28%~~	Alpaca	25%	290 gsm

Results from performance tests conducted by CSIRO are reproduced in Appendices A and B. The following sections provide supplementary information on flammability tests (Section 1) and filtration performance (Section 2).

1 Flammability Testing

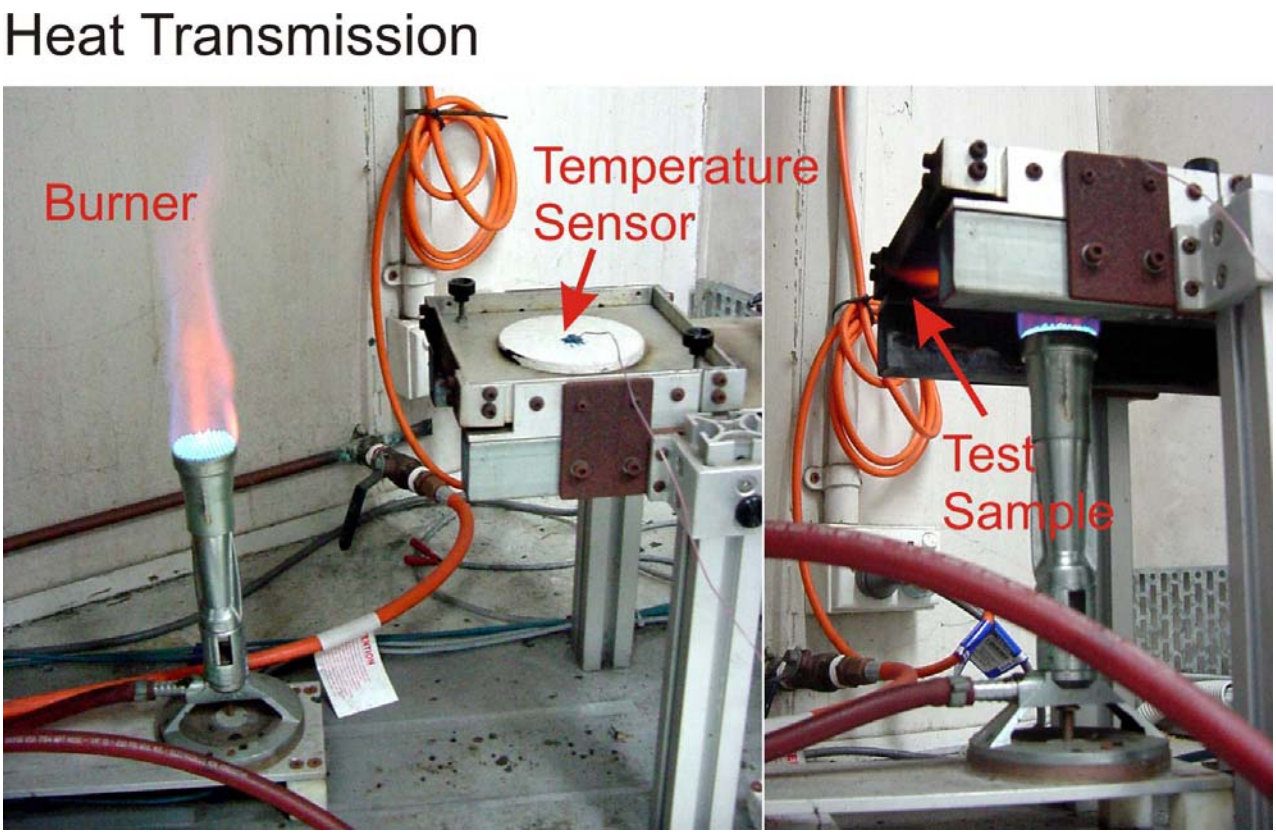
1.1 Heat Transmission

The test conforms to specifications and protocols described in ISO Standard 9151:1995 (E) [1]. Figure 1 provides details of the setup showing the Bunsen burner, fabric holder and temperature sensor. Test results are reproduced Figure A.1 of Appendix A.

The temperature sensor measures the temperature change above the fabric with time. Measurement t_{12} and t_{24} represent the time required to register a temperature increase of 12 ^{o}C and 24 ^{o}C, respectively.

The value of t_{24} must be greater than 17 seconds to pass the test, which was fulfilled by both media MTR05 and MTR06.

Figure 1: Test set up for Heat Transmission measurement.



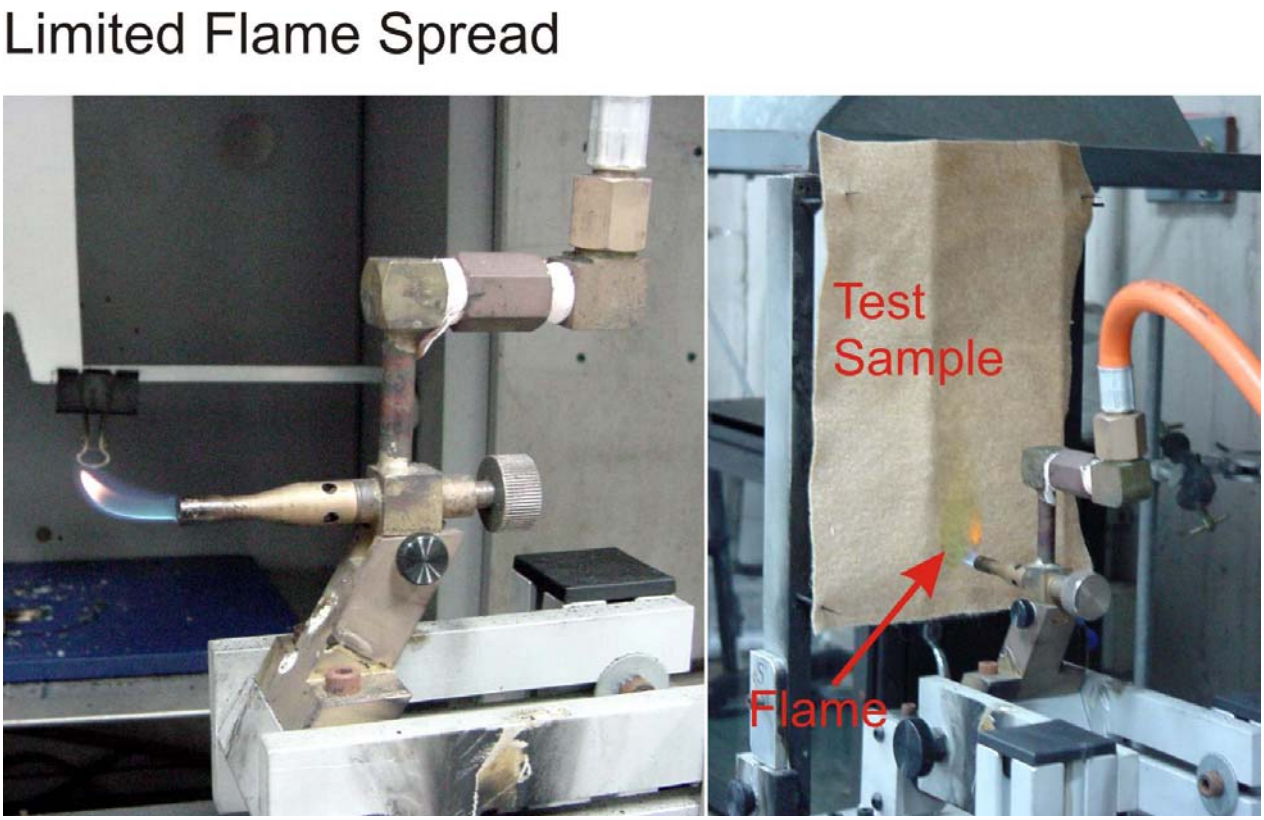
1.2 Limited Flame Spread

The test conforms to specifications and protocols described in ISO Standard 15025:2000 [2]. Figure 2 provides details of the setup showing the burner aligned in a horizontal position with flame adjusted to size (left) and a fabric (a different specimen) mounted and subjected to the flame. Test results are reproduced Figure A.2 of Appendix A.

The “Afterflame Time” specifies the duration during which the test specimen was burning: a value of zero indicates that the fabric either did not catch fire during the whole flame application time of 10 seconds

duration or that the specimen stopped burning immediately after the burner flame was removed. All specimens passed the test.

Figure 2: Test set up for Limited Flame Spread measurement.



2 Description of the Filtration Test Method

A picture of the filter test equipment is shown in Figure 3. The filtration test involves subjecting a test sample to a challenge of potassium chloride particles from an atomiser. The filtration efficiency is calculated from particle concentrations measured upstream and downstream of the filter sample by means of two optical particle sizers. The PMS HandiLaz particle sizers provide particle counts size resolved in four fractions of 0.3 to 0.5 µm, 0.5 to 1.0 µm, 1.0 to 5.0 µm and >5.0 µm. The pressure differential across the filter sample that is built up by the air flow through the medium is measured by an electronic pressure sensor. This pressure differential is called “pressure drop”.

Figure 3: Image of the Particle Counter Filter Test Instrument (PCFTI) with HandiLaz Particle Counters.

2.1 Performance Benchmark: Quality Factor

Since filtration efficiency and pressure drop are both affected by properties such as fabric thickness or fabric density, it is generally useful to calculate a benchmark called “quality factor” as follows:

$$Q = \frac{-\ln(P)}{\Delta p} \quad (1)$$

In this equation P denotes the penetration, which is equal to (1 – FE/100) with FE denoting filtration efficiency in percent, ln() the natural logarithm and Δp the pressure drop. This benchmark allows comparisons to be made between different media in terms of the quality of the filter medium (e.g. evenness) and strongly suppress the influence of thickness, fabric weight or packing density.

A modified definition of the quality factor is used that accounts for the influence of face velocity vf:

$$Qx = Q \cdot \Delta p \cdot \eta \quad (2)$$

The dynamic viscosity η is introduced because this extension is based on Darcy’s Law.

A brief discussion of filter test results is provided in the following. Please refer to Appendix B for detailed information on individual measurements.

2.2 Filtration Test Reports

Appendix B provides data on mechanical properties of a medium and of its filtration performance. Results are colour-coded in the body and header of each table: Blue/green for information on the media, burgundy for sample properties and black/red for filter test results.

Each measurement contains information on date and time when the measurement was taken, face velocity in metres per second, filtration efficiencies for the four size fractions (“FE (%SD) 0.3 [µm]” to FE (%SD) 5.0 [µm]” in percent), the pressure drop in Pascal, the quality factor Q for the four size fractions (e.g. “Q0.3 [1/kPa]” for the 0.3-0.5 µm size fraction) and the same for quality factor Qx.

The quality factor Q for purely mechanical filter media without electrostatic charge has an upper ceiling value of approximately 20 kPa^{-1} for the 0.3µm to 0.5µm particle size fraction (Q0.3) if measured with this particular instrument (PCFTI). It is fairly independent of fibre diameter (ranging from 100nm to 50µm) and packing density (within 3% to 20%) and provides therefore an excellent general benchmark for filtration performance. Deviations of the quality factor Q from the ceiling value, if measured at a fixed face velocity, are due to compromises in evenness (accounting for a lower value) or the presence of electrostatic charge (leading to an increase).

The value of “Q0.3”, which is the value of the quality factor Q for the 0.3µm-0.5µm particle size fraction, is of particular interest because this benchmark takes on a value of 20 kPa^{-1} if the web structure is uniform and not charged. However, if high levels of electrostatic charge are present, this value can be one order of magnitude higher. That means that the positive control for this filter medium is the target of reaching a value of Q0.3 ≈ 200 kPa^{-1}.

Certification requirements for filter media designated for use as a respirator are outlined in Australian Standard AS/NZS 1716 [3]. According to the 1994 edition of the standard, the penetration of a Class P1 respirator must be not more than 20% if subjected to nebulised sodium chloride test particles under simulated test conditions. A filtration efficiency greater than 80% from tests conducted on the PCFTI provides an indication of the performance potential that a filter medium can achieve, but does not satisfy the requirements of certification according to the Australian Standard because the test is not conducted according to the required test conditions.

Appendix A - Flammability Tests

Apx Figure A.1: Heat Transmission on Exposure to Flame

CSIRO- Materials Science & Engineering (ABN: 41 687 119 230)
Henry St, Belmont, Victoria 3216, Australia.
Telephone: (03) 52464000 Fax: (03) 52464057
Email: texlab@csiro.au Web: http://www.tft.csiro.au

CSIRO

Textile Testing Laboratory

TEST REPORT

Report Number: 10-0948 **Page** 1 of 2 **Date Issued**: 22/12/2010

Client: Dane Taylor Tech
Contact: Mike Taylor
Address: 312 Mandurang South Road
Mandurang South Vic 3551

Sample Description: 5 x layer structure (respirator medium), nominally fire-resistant cotton?alpaca%&%&%&%&%&%&%&%&%&%&%&%&%&alpaca
Sample Reference: MTR06, MTR05 (without %%%%%%)

Test Method	Result	Unit
ISO 9151:1995 (E)		
PROTECTIVE CLOTHING AGAINST HEAT AND FLAME – DETERMINATION OF HEAT TRANSMISSION ON EXPOSURE TO FLAME.		
t_{12}	25.2 21.6	s
t_{24}	36.0 30.2	s
Heat Transfer Index (mean t_{24})	33.2	s
Any changes in appearance:		

Test Conditions: **Temperature** 16.9°C **Relative Humidity** 59.4% **Incident Heat Flux** 80 kW/m^2

CSIRO

The results contained in this report apply only to the sample submitted to the laboratory. This report must not be reproduced without the written authority of the laboratory and then shall only be reproduced in full.

Approved by: **D.R. Carroll - Laboratory Manager**

Australian Science, Australia's Future

Apx Figure A.2: Method of Test for Limited Flame Spread

CSIRO- Materials Science & Engineering (ABN: 41 687 119 230)
Henry St, Belmont, Victoria 3216, Australia.
Telephone: (03) 52464000 Fax: (03) 52464057
Email: texlab@csiro.au Web: http://www.tft.csiro.au

CSIRO

Textile Testing Laboratory

TEST REPORT

Report Number: 10-0948 **Page** 2 of 2 **Date Issued**: 22/12/2010

Client: Dane Taylor Tech
Contact: Mike Taylor
Address: 312 Mandurang South Road
Mandurang South Vic 3551

Sample Description: 5 x layer structure (respirator medium), nominally fire-resistant cotton?alpaca [illegible] alpaca
Sample Reference: MTR06, MTR05 (without [illegible])

Test Method	Result	Unit

ISO 15025:2000
PROTECTIVE CLOTHING – PROTECTION AGAINST HEAT AND FLAME
METHOD OF TEST FOR LIMITED FLAME SPREAD
Procedure A – SURFACE IGNITION: Flame application time 10 s

Specimen	Afterflame Time (s)	Afterglow time (s)	Proc A Hole Size (mm)
1	0	0	0
2	0	0	0
3	0	0	0

Observations:
No flame reached the upper and/or vertical edges on three specimens.
No afterglow spreads beyond the flame spread area into undamaged area.
No holes developed in three specimens

Test Conditions: **Temperature:** 16.9°C **Relative Humidity:** 59.4% **Gas used:** Propane

Approved by: **D.R. Carroll - Laboratory Manager**

Appendix B - Filtration Test Data

Apx Figure B.1: Particle Counter filter tests: individual measurements and averages

Filtration Efficiency Test Report

Mike Taylor – Dane Taylor Tech

CSIRO

Service Description

Characterise two multi-layer composite media supplied by Mike Taylor subject to filtration efficiency testing using fine particles of potassium chloride under following conditions:

- Flow rates: 55 LPM (0.15 m•s^{-1} face velocity)
- Aperture size: 89 mm (sample diameter of 109 mm)

Details of the fabric samples:

Medium	MTR05	Share	MTR06	Share	Basis Weight
Front	Fire-resistant cotton	25%	Fire-resistant cotton	21%	250 gsm
2	Alpaca	28%	Alpaca	25%	290 gsm
3	[illegible]	19%	[illegible]	16%	185 gsm
4	-		[illegible]	13%	155 gsm
Back	Alpaca	28%	Alpaca	25%	290 gsm

Filter Test Results

A circular sample of 109mm diameter was cut from the test fabric and subjected to potassium chloride fine particle filter testing.

Fabric Properties

Measured properties of the multi-layer test samples are provided in Table 1.

Table 1: Mechanical properties of the multi-layer fabric samples

Medium	No of layers	Thickness	Basis Weight	Fabric Density
		(mm)	(g/m^2)	(kg/m^3)
MTR05	4	11.7	1005	86
MTR06	5	14.4	1180	82

Filter Test Results

Filter test results for a face velocity (v_i) of 0.15 m/s are summarised in Table 2. Filtration efficiencies FE and quality factors Q are provided with the lower particle size limit as index.

Table 2: Measured pressure drop as well as filtration efficiencies and quality factors for 0.3µm, 0.5µm, 1.0µm and >5.0µm particles of media "MTR05" and "MTR06".

Medium	Pressure Drop	$FE_{0.3}$	$FE_{0.5}$	$FE_{1.0}$	$FE_{5.0}$	$Q_{0.3}$	$Q_{0.5}$	$Q_{1.0}$	$Q_{5.0}$
	(Pa)	(%)	(%)	(%)	(%)	(kPa^{-1})	(kPa^{-1})	(kPa^{-1})	(kPa^{-1})
MTR05	33.7	28.8	35.9	47.3	84.4	10.1	13.2	19.0	56.0
Std Dev	*1.5*	*2.0*	*2.5*	*1.4*	*4.4*	*0.9*	*1.2*	*0.8*	*7.4*
MTR06	41.5	98.6	99.2	99.6	100.0	103.9	117.5	134.8	-
Std Dev	*1.5*	*0.1*	*0.1*	*0.1*	-	*2.8*	*2.6*	*4.5*	-

Results from individual measurements are provided in the Appendix.

Filter Test Report – 16 December 2010 1

Appendix

Measured Data Set

Filter Properties Test Results (PCFTI)

MediumID / No	Structure / Thickness	Charging / Sample Wt.	Component 1 / 2 / 3 / Basis Wt.	Fabric Density / Packing Dens.	Composition / Avg. Mat. Dens / Comp. 1 Only	Experimental Trial / Test Type
Date/Time	Time diff [d]	FE 0.3-0.5-1.0-5.0 [um]	Pr. drop [Pa]	Vf [m/s]	Q0.3 [1/kPa]	Q0.5 [1/kPa]	Q1.0 [1/kPa]	Q5.0 [1/kPa]	Qx0.3 [nm]	Qx0.5 [nm]	Qx1.0 [nm]	Qx5.0 [nm]
MTR05	Comp. _	Alpaca Beige	/ Carbon Cloth	/ Cotton	56-18-25	1348.6 [kg/m^3]	Alpaca Respirators					
No 1	11.677 [mm]	9.4956 [g]	1005.3 [g/m^2]	86.1 [kg/m^3]	0.0638 [1]	/ 0.0000 [1]	PcFeTm					
16/12/2010 14:26:47	0.00	28.35	32.66	48.53	82.75	33.5	0.1378	9.95	11.80	19.83	52.46	28.58	33.89	56.95	150.66
16/12/2010 14:28:24	0.00	27.95	34.65	47.97	87.92	34	0.1530	9.64	12.51	19.22	62.17	26.84	34.84	53.52	173.12
16/12/2010 14:30:06	0.00	28.83	37.72	46.57	76.32	33.8	0.1530	10.06	14.01	18.54	42.62	28.01	39.01	51.63	118.68
16/12/2010 14:31:50	0.00	32.61	38.41	48.78	86.99	33.5	0.1530	11.78	14.47	19.97	60.88	32.80	40.29	55.61	169.53
16/12/2010 14:33:28	0.00	26.75	38.23	46.68	86.02	33.8	0.1378	9.21	14.25	18.61	58.21	26.45	40.93	53.45	167.18
16/12/2010 14:35:14	0.00	28.34	33.86	45.17	86.69	33.8	0.1378	9.86	12.23	17.78	59.66	28.32	35.12	51.06	171.34
MTR06	Comp. _	Alpaca Beige	/ Carbon Cloth	/ Cotton		1310.0 [kg/m^3]	Alpaca Respirators					
No 1	14.418 [mm]	11.1311 [g]	1178.4 [g/m^2]	81.7 [kg/m^3]	0.0624 [1]	/ 0.0000 [1]	PcFeTm					
16/12/2010 14:55:45	0.00	98.48	99.19	99.52	100	41.5	0.1378	100.88	116.05	128.65	0.00	289.72	333.29	369.48	0.00
16/12/2010 14:57:27	0.00	98.63	99.22	99.6	100	41.8	0.1530	102.64	116.12	132.09	0.00	285.81	323.35	367.82	0.00
16/12/2010 14:59:09	0.00	98.71	99.18	99.68	100	41.3	0.1530	105.34	116.31	139.09	0.00	293.33	323.88	387.31	0.00
16/12/2010 15:00:55	0.00	98.62	99.31	99.69	100	41.3	0.1435	103.71	120.49	139.86	0.00	270.86	314.68	365.27	0.00
16/12/2010 15:02:42	0.00	98.87	99.33	99.67	100	41	0.1435	109.34	122.09	139.36	0.00	285.56	318.86	363.97	0.00
16/12/2010 15:09:57	0.01	98.57	99.23	99.61	100	41.8	0.1530	101.61	116.42	132.70	0.00	282.94	324.18	369.52	0.00
16/12/2010 15:11:51	0.01	98.64	99.16	99.58	100	41.5	0.1530	103.56	115.17	131.87	0.00	288.37	320.70	367.21	0.00

Thursday, 16 December 2010 Page 1 of 1

CSIRO Materials Science and Engineering

Contact Jurg A. Schutz, PhD
Principal Scientist, Filtration

Phone (+61 3) 5246-4749

Fax (+61 3) 5246-4057

Mobile 0447 321 561

Email Jurg.Schutz@csiro.au

Shortened forms

The following abbreviations, initialisms, acronyms or shortened forms have been used within this report:

FE	Filtration Efficiency
PCFTI	Particle Counter Filter Test Instrument
PP	Polypropylene
P	Penetration

Glossary

Filtration Efficiency (FE)	The percentage of particles removed from an aerosol streaming through a filter medium under test. It is related to penetration P by FE = 100% * (1-P).
Penetration (P)	The ratio of particles passing through a filter medium under test to the number of particles it was subjected to.
Pressure Drop (Pd)	The differential pressure that a stream of aerosol generates with passing through a filter medium.
Quality Factor (Q)	A filtration performance benchmark calculated according to equation (1) in Section 2.1.

References

1. ISO, *9151:1995(E) PROTECTIVE CLOTHING AGAINST HEAT AND FLAME -- DETERMINATION OF HEAT TRANSMISSION ON EXPOSURE TO FLAME*, 1995, INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO).

2. ISO, *15025:2000 PROTECTIVE CLOTHING -- PROTECTION AGAINST HEAT AND FLAME -- METHOD OF TEST FOR LIMITED FLAME SPREAD*, 2000, INTERNATIONAL ORGANIZATION FOR STANDARDIZATION (ISO).

3. COMMITTEE_SF/10_INDUSTRIAL_RESPIRATORY_PROTECTION, *AS/NZS 1716:1994 RESPIRATORY PROTECTIVE DEVICES*, 1994, STANDARDS AUSTRALIA, 1 THE CRESCENT, HOMEBUSH, NSW 2140, AUSTRALIA.

CONTACT US

t 1300 363 400
+61 3 9545 2176
e enquiries@csiro.au
w www.csiro.au

YOUR CSIRO

Australia is founding its future on science and innovation. Its national science agency, CSIRO, is a powerhouse of ideas, technologies and skills for building prosperity, growth, health and sustainability. It serves governments, industries, business and communities across the nation.

FOR FURTHER INFORMATION

CSIRO Materials Science and Engineering, Fibre Physics and Engineering
Jurg Schutz
t +61 3 5246 4749
e Jurg.Schutz@csiro.au
w http://www.csiro.au/org/CMSE