Australian science behind market-first plastic mirror

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In transport industries, metal and glass are increasingly being replaced by lightweight yet durable plastic parts, which can be easily moulded into dynamic shapes, and don't shatter on impact. Capitalising on this transition, Australian scientists have developed a market-first plastic wing-mirror that has led to US$162 million worth of sales to Ford.


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An advanced thin-film manufacturing process could see lightweight plastics replacing glass windows and mirrors in a range of passenger vehicles, offering enhanced fuel efficiency and safety.

The lead inventor of the process is Dr Colin Hall from the Future Industries Institute (FII) at the University of South Australia (UniSA). In collaboration with SMR, an Indian-owned automotive parts manufacturer in Adelaide, Hall's team has developed a market-first plastic wing-mirror.

The mirror can be more easily moulded into dynamic shapes than glass, or curved to provide a wider field-of-view for drivers. It's also half the weight, less prone to vibration, easier to assemble in its casing, water repellent, and shatterproof in the event of a collision.

SMR Technologies, a spin-off resulting from the collaboration, has manufactured and exported 1.6 million plastic wing-mirrors worth US$162 million to the United States since 2012, where they are used exclusively in Ford F-Series pick-up trucks.

SMR is still the only parts manufacturer worldwide with a plastic mirror product that meets strict automotive industry requirements for safety, function and durability across extreme weather conditions.

In recognition of the jobs created in Australia's manufacturing sector as a direct result of the collaboration between UniSA and SMR, Hall was honoured at the 2016 Prime Minister's Prizes for Science in October, winning the Prize for New Innovators.

> "My feet still haven't hit the ground," he says of the ceremony.

Colin Hall giving his acceptance speech at the Prime Minister's Prizes for Science in October. Credit: Wildbear.

Forming a plastic partnership

Hall was a PhD candidate at the UniSA investigating ultra-thin protective surface coatings when SMR approached his research group to give feedback on the performance of a plastic mirror it had been developing. To ensure an unbiased assessment, the company provided a range of prototypes being worked on by companies across the industry.

Each had been developed in a similar manner: a metal reflective layer had been placed directly onto a plastic substrate. This metal layer was then covered with a clear hard-resin coating, or protective layer.

"In every mirror that I came across there were fundamental flaws," Hall says.

The layers weren't bonding well, were failing accelerated weathering tests when exposed to different temperatures, humidity levels and light intensities, and the metal reflective mirrors were susceptible to scratching. The protective layer also needed to be thinner.

Hall was in a unique position to help address these shortcomings. After completing an undergraduate degree in applied physics at UniSA in the early 1990s, he worked for the Australian spectacle company SOLA Optical for nine years, developing anti-reflective coatings for plastic lenses.

Fixing the mirror with a multi-layer stack

Inspired by his experience at SOLA Optical, Hall made a counterintuitive decision to put the hard coating underneath the reflective metal, which dramatically improved bonding.

Now the challenge was to make the top metal layer durable enough to survive harsh automotive tests. Hall and his team developed a new approach, incorporating five thin-film layers, using materials already applied in the automotive industry, and stacking them to maximise adhesion.

Colin Hall in his lab at the University of South Australia in Adelaide. Credit WildBear

The first layer, applied directly to the plastic base, was a thick (3 micrometre) resin hardcoat. This was followed by a 200-nanometre layer of glass-like silicon dioxide, which reduced temperature stress and increased abrasion resistance. For the reflective mirror layer, the team developed a corrosion- and scratch-resistant chrome zirconium alloy. This reflective metal was capped with another ultra-thin (10 nanometre) layer of silicon dioxide, which further enhanced scratch resistance. Finally, they applied a 10-nanometre water-repellant layer, which made the mirror easier to clean. Importantly, these top two layers are clear and don't affect the optical properties of the reflective metal.

The team had received funding from the Auto Cooperative Research Centre (now Excellerate Australia) since 2008. By 2010, SMR was convinced enough by the team's progress to invest in a pilot manufacturing facility in Adelaide to create the thin-film stacks.

Hall worked with the company to scale-up production, and during concept stages, helped troubleshoot any issues with the design and manufacturing process. By 2012, they had perfected their plastic mirror – the first of its kind globally. The mirror was available for sale in the same year.

Halls says out of 1.6 million products sold, SMR has only had about 10 mirrors returned.

“If it was glass they would have expected a two per cent return rate,” says Hall, which is equivalent to about 32,000 mirrors. This is because glass mirror panes are sometimes too big for their plastic casings, and break over time as a result of stress.

“If anyone else wants to come in and make a plastic mirror, they’ll have to perform to our highest specification,” says Hall.

Deep engagement with industry

Colin Hall in his lab at the University of South Australia in Adelaide. Credit WildBear

The FII was established at UniSA in 2015 to help companies capitalise on disruptive technologies, which are transforming existing industries and catalysing new ones.

The FII’s focus is in the areas of minerals and resources engineering, environmental science, bioengineering and nanomedicine, and energy and advanced manufacturing. Academics work collaboratively with industry partners in these areas to define a problem, map out possible approaches, set realistic targets, and create new knowledge and innovative technologies.

The thin-film manufacturing partnership with SMR has exemplified these objectives. Not only was there a major commercial success story, but Hall developed an immersive research-industry training program, which saw UniSA and SMR personnel embedded in each other’s labs and manufacturing facilities, learning from each other, and sharing resources and ideas.

It’s a model the FII has replicated for other projects, and Hall says it has allowed the institute and SMR to continue working “hand-in-hand”.

SMR Technologies has had discussions with several major European car manufacturers about a range of replacement parts that use their thin-film coatings. These include electroplated chrome plastic badges and grilles, which require carcinogenic materials during the production stage.

Hall and his colleagues at the FII are also forging new partnerships. With the Malaysia Automotive Institute and Excellerate Australia, they are looking at creating durable plastic windows for electric buses, which reflect infrared light to keep heat out. The windows will makes buses lighter, safer in the event of an accident, and will save energy on airconditioning.

> “Our work shows that universities can work with industry to have a real impact,” says Hall. “We want to continue to help companies innovate, and seed the next generation of manufacturing for Australia.”

- More about the University of South Australia.
- More about the Future Industries Institute.
- More about the Prime Minister's Awards for Science.
