ARMSTRONG WORLD INDUSTRIES, INC.

New Materials for New-Generation Thermal Insulation

Armstrong researchers planned to investigate the microstructure of insulation material and the air cells, or pores, within it. The project aimed to learn how to control the molecular morphology — structure — of the solid material (to reduce its thermal conductivity), the geometry and orientation of air cells (to optimize pore morphology), and the size and distribution of air cells (to reduce the thermal conductivity of air within a cell).

COMPOSITE PERFORMANCE SCORE
(Based on a four star rating.)

No Stars

Developing Super Insulating Materials

Although they were not able to fully achieve their goals, the researchers made important progress in the development of super insulating materials as a result of their study of materials with high porosity and of nonspherical pores that are nanometer in size. The technical work followed two major tracks: the fabrication of polyethylene and polystyrene foams with carbon dioxide blowing while attempting explicitly to control the formation of the air pores, and the development of new process technology for the synthesis of aerogels for use in insulation products.

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The blowing of polyethylene and polystyrene foams with carbon dioxide entailed substantial challenges in attempting to optimize the mechanics to achieve the foam without a pressure drop leading to collapse of air cells. The researchers ran into problems working with polyethylene and, in addition, concluded that modification to extruder equipment would be necessary to achieve success with carbon dioxide as the blowing agent. Both changes raised production costs. Armstrong subsequently shifted away from polyethylene to other thermoplastics and began blowing with butane, in addition to carbon dioxide, but costs could not be lowered enough to justify commercialization. No patents or papers resulted from this track of the ATP-sponsored research.

Researchers achieved more technical success in their work on process technology for the synthesis of aerogels. The aerogels and xerogels produced by the process have both a high porosity and small pores; that is, the resulting material is microporous, with about 25 percent of the pore volume in pores less than 50 nanometers in diameter. The process also promises to substantially lower the costs of aerogel production. Armstrong received three patents for its technical advances in aerogel synthesis.

Company Shifts

At the time the project was awarded, Armstrong saw the ATP project as providing an opportunity to broaden the company's capabilities along lines that it otherwise would not have pursued. By developing new forms of insulation with superior performance, Armstrong saw the opportunity to broaden its focus from the technical insulation market (insulation for heating, refrigeration, plumbing, and specialty applications) to the structural insulation market (insulation for buildings and other large structures). Armstrong officials expected their first aerogel application to be for rigid technical insulation, with eventual opportunities in structural applications.

Later company reorganizations and strategy shifts changed the company's plans for applying its new technical know-how. Armstrong officials concluded that — despite the remarkable insulating properties of the aerogels

PROJECT HIGHLIGHTS

PROJECT:
To develop process technology for a new-generation insulation material based on controlled morphology (structure) in order to achieve superior insulating properties and associated energy savings.
Duration: 8/1/1992 — 7/31/1995
ATP Number: 91-01-0146

FUNDING (in thousands):

ATP	$1,868	41%
Company	$2,650	59%
Total	$4,518	

ACCOMPLISHMENTS:
Armstrong researchers performed research in two major areas: process technology for aerogels and carbon dioxide blowing of polyethylene foams. The company received three patents for technologies related to the ATP project:

- "Preparation of High Porosity Xerogels by Chemical Surface Modification"(No. 5,565,142: filed 4/28/1993, granted 10/15/1996);
- "Thermally Insulative, Microporous Xerogels and Aerogels" (No. 5,525,643: filed 7/28/1995, granted 6/11/1996); and
- "Wet Silica Gels for Aerogel and Xerogel Insulation and Processes for the Wet Gels"(No. 5,762,829: filed 3/5/1997, granted 6/9/1998).

CITATIONS BY OTHERS OF PROJECT'S PATENTS: See Figure 6.2.

COMMERCIALIZATION STATUS:
Armstrong has decided to license its low-cost aerogel synthesis patents to suppliers, rather than to manufacture aerogels directly, but the licensing has not yet occurred.

OUTLOOK:
Despite extremely good insulating properties of the aerogels and lowered processing costs, early applications of the aerogel are expected to be limited to niche markets, such as rigid technical insulation for heating, refrigeration and plumbing, or to speciality applications such as superconductivity insulation. Even with lowered costs, the aerogels do not at this time appear to be cost-competitive with conventional insulation materials for structural applications. Armstrong is continuing its research on the use of carbon dioxide foaming of thermoplastics, and this approach may hold promise for the future.

Composite Performance Score: No Stars

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and the new process technology, which dramatically reduced production costs — the unit costs were still too high to penetrate the structural insulation market. The company's initial excitement over the potential of aerogels for the structural market dimmed. Armstrong scaled back its estimated demand for aerogels and decided to procure what it needed through suppliers rather than produce them in-house.

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The company has decided to license the three aerogel process patents to potential suppliers, and not to be in the aerogel manufacturing business itself. To the extent that suppliers who obtain the licenses can use technology to produce aerogels more cheaply, Armstrong will benefit from its research in terms of a lower-cost supply. Other buyers may also benefit from lower-cost aerogels, depending on the specific licensing arrangements negotiated by the suppliers with Armstrong. Thus far, no licensing agreements have been achieved. But, according to company officials, Armstrong stands ready to negotiate licensing agreements for its aeorogel process technology.

In fall 1996 Armstrong combined, with another unit, the research unit where the ATP project was carried out, a consolidation that also entailed personnel changes. The principal investigator on the ATP project left Armstrong and set up a separate business that is reportedly working in areas related to the ATP project. This movement of people who worked on the research project and the establishment of a new business pursuing related technological goals may provide yet another possible path of technology diffusion.

Over time, Armstrong's primary interest has shifted away from the aerogel technology and toward the foam blowing technology, as indicated by the company's continued involvement in this area. Here, too, Armstrong's research effort shifted away from the initial ATP project focus toward techniques and materials that now are seen to offer more promise of achieving the high-performance foam insulating products that were the ultimate goal of the ATP-funded research.

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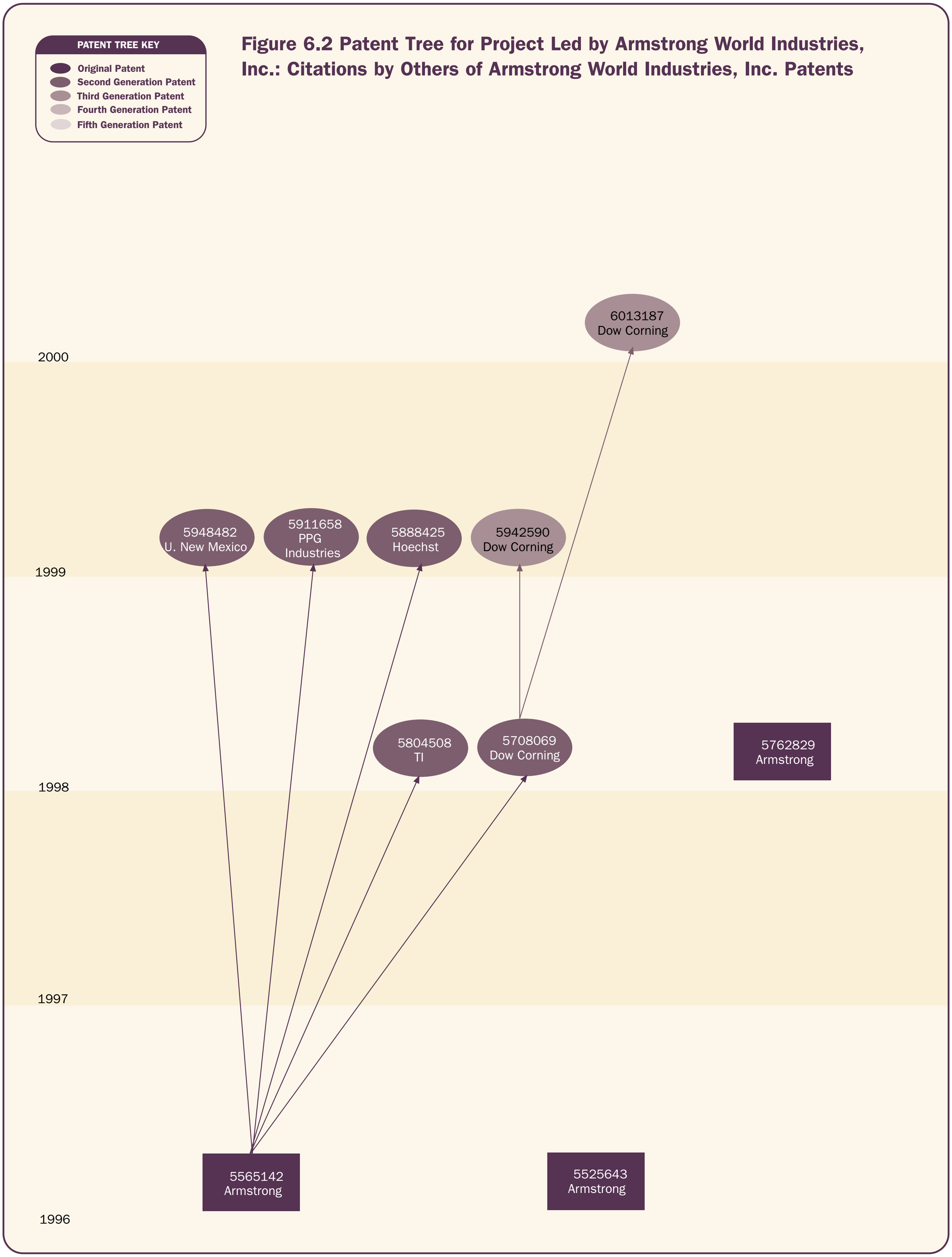
PATENT TREE KEY
Original Patent
Second Generation Patent
Third Generation Patent
Fourth Generation Patent
Fifth Generation Patent
Figure 6.2 Patent Tree for Project Led by Armstrong World Industries, Inc.: Citations by Others of Armstrong World Industries, Inc. Patents
6013187
Dow Corning
2000
5948482
U. New Mexico
5911658
PPG
Industries
5888425
Hoechst
5942590
Dow Corning
1999
5804508
TI
5708069
Dow Corning
5762829
Armstrong
1998
1997
5565142
Armstrong
5525643
Armstrong
1996