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About the Cover
Testing various bond strengths of honeycomb core-to-film adhesive/metal surfaces shown in upper right (photos courtesy Wyoming Test Fixtures and University of Utah). Bottom four photos courtesy of Dr. Rik Heslehurst showing various bond lines and “close-out” section bonding with core materials to composite laminates.
As my first important contribution as the SAMPE Global President, I served as chair in SAMPE Global Board of Directors’ meeting held in Amiens, France, at the occasion of the SAMPE Europe 2015 Conference. One important issue on its agenda was an application to form new China Mainland Region from existing two Beijing and Shanghai Chapters. This application was approved unanimously. I believe this kind of movement is one of the most important incentives as we transition from SAMPE International to SAMPE Global. In that sense, this proposal from the two Chinese Chapters is the most welcome and appropriate step which is compatible to the initial basic philosophy of SAMPE globalization. I hope the new China Region will grow sustainably and contribute to the whole prosperity of SAMPE Global systems.

The second important discussion point was by-law changes regarding global and international past president structures. This agenda was proposed by Dr. Brent Strong, one of the global Board of Directors’ of North America Region. After discussions, this agenda was approved to rename the past president structures to avoid confusions.

The third important proposal is a motion to change a new SAMPE logo. Although the current logo is historical and attracting sympathetic feelings, some SAMPE members started to understand its defects in several points. Mr. Gregg Balko explained the backgrounds of this movement and examples of logo changes happened in some other sectors. After serious discussions, it was approved to start this motion with a careful selection of a professional design firm. It was also decided that the next SAMPE global Board of Directors’ meeting will be held at the next CAMX meeting in Anaheim, CA, USA in late September 2016.

The SAMPE Europe 2015 conference itself was a very good and active meeting full of interesting presentations under the new strategy of SAMPE Europe Region. A good balance in topics between aerospace and other newly growing fields like automotive applications was well organized. Another good balance between industrial and academic research directions which is the best feature in all SAMPE meetings was also well perceived.

Moreover, one very impressive technical tour to Stelia Aerospace took place to a plant near Amiens on the first day. This plant is producing the nose components of the Airbus A350 XWB, assembled structures composed of a metal cockpit, and stiffened composite curved shells. I believe that all the participants could feel their enthusiasm to realizing the highly automated fabrication processes particularly in composite component productions, which must be very crucial in future commercial aircraft production businesses. Thus, three days in Amiens for me were completely fruitful and satisfactory.
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Networking, Technical Exchange and Cross-Fertilization – All Important

As the premier technical professional society that addresses advancing materials and process engineering technology SAMPE Global, knows very well the importance of technology exchange. As a technical society SAMPE organizes numerous annual conferences, workshops, seminars and regional events in order to advance technology. Quite often SAMPE members, officers and staff are asked to participate in other technical society events in order to share much of our advanced technology. That interface and interaction with other societies encourages new ideas and “cross-fertilization”.

Recently, SAMPE was invited to participate in the Materials Research Society's Mexico conference in Cancun, Mexico during the summer. The MRS-SAMPE participants were organized into providing several short (1.5 hour) interactive lectures on various aspects of advanced materials technologies. SAMPE provided a presentation on how manufacturing defects get into polymer matrix composites. The presentation and discussion between presenter and audience elicited numerous questions regarding types of defects, how to detect them, and why they occur in the first place. Comparisons between advanced composites defects in aerospace vs. consumer products were also presented and discussed. MRS particularly organized the session to make sure that much of the audience was students more so than professionals already engaged in advanced composites.

However, more important to this particular mutual engagement between societies was the networking and technology interchange that developed between topics, speakers and different technologies. I point to the latter area because the other two professional presenters address areas that, while similar to SAMPE in technology, opened up the observation to those technologies being potentially applied to other fields. One of the presenters from NASA discussed various means of preventing or at least retarding corrosion growth in metallic materials. The technology involved encapsulated chemical species which had a timed release in coatings and paints. Over time, this time release continues to retard corrosion in NASA structures. As I listened to the presentation, the potential for similar methodology and approach to composite problems associated with service life aging, detection of impact events in composite structures, and various health monitoring aspects – all seem to have similar application potential. “Cross-fertilization”! We need to look at other technologies and examine their potential for addressing solutions to known deficiencies in our own realm of technology.

The second speaker, also from NASA, addressed graphene materials. Thinking about what he was saying suggested there are areas that appear to have potential. The bottom line is that very often technologies developed for one focus area can have similar application in vastly different other technologies. These types of “inter-society” conference technology presentations can often lead to a great technology exchange of new ideas and new applications. To that end I personally found the exchange between MRS and SAMPE very beneficial. SAMPE’s Past President, Dr. Tia Benson Tolle was the instigator for this particular interaction with MRS and deserves our thanks.
SAMPE is honored to have these three association professionals as part of our staff team. Between the three of them, they have worked in nearly every aspect of what we do. Priscilla started in our accounting department, Sylvia was a backup receptionist and oversaw our building services, and Rosemary in membership. Now, they are known as our “go to” experts for registration, board of directors and executive cabinet services and convention management. For over two decades, each has been committed to delivering five-star levels of service.

Congratulations and Thank You for your service, Priscilla, Sylvia and Rosemary!
Feature Article

Cleaner Surface Preparation for Bonding Using CO₂ Technology

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Abstract
Bonding processes by any method and for any purpose permit the utilization of new engineered materials in combination with transformative design concepts. Appropriate surface preparation is the essential first step to provide consistent and reliable adhesive or cohesive bond strength. Conventional surface treatment options for joining substrates pose different constraints in terms cost of ownership, environmental compliance, and performance. Carbon dioxide (CO₂) based processing alternatives offer an effective, eco-friendly and robust platform for preparing many types of substrate surfaces for numerous medical, aerospace, automobile, ophthalmic and microelectronic bonding applications.

Introduction
Bonding is the act of assembling (or joining) similar or dissimilar materials in order to build complex structures or devices, or the creation of new beneficial surfaces that address technological needs such as joint strength, abrasion resistance, corrosion resistance, or biocompatibility. Bonding technologies are numerous and include adhesive bonding, mechanical fastening, laser welding, soldering, brazing, acoustic bonding, diffusion bonding, isothermal solidification bonding, transient liquid phase bonding, exothermic bonding, dip coating, and thermal spray coating, among many other examples.

Bonding processes by any method and for any purpose permit the utilization of new engineered materials (i.e., alloys, composites, nanostructured materials, advanced medical devices) in combination with transformative design concepts. In many cases, the methods by which materials are assembled or joined are as important if not more important than the materials used. As such the bonding requirement is critical in the design and manufacturing phase.

The range of industries and applications requiring the production of mechanically strong joints or durable surface adherents such as paints and coatings which can survive challenging environments (i.e., pressure, strain, heat, cold, UV, ozone, steam, moisture, human body) are abundant. A few examples relevant to this article include:

- Electronics – wire bonding and soldering (metal-to-metal surface bonding)
- Ophthalmic – anti-reflective and anti-abrasion coatings (organic coating-to-thermoplastic surface bonding)
- Medical Device – adhesive joining of low energy plastics (polymer-to-polymer surface bonding) and coating (organic-to-composite surface bonding)
- Automotive – welding (metal-to-metal surface bonding) and painting (organic coating-to-composite surface bonding)
- Aerospace – thermal spray coating (metal coating-to-metal surface bonding) and sealants (organic-to-composite surface bonding)

Manufacturing a Bonding Surface
Appropriate surface preparation is the essential first step to provide consistent and reliable adhesive or cohesive bond strength. As described in Figure 1 major bonding elements comprise substrate, adhesive, bondline surface area and joint design. Key bonding factors that influence adhesion are represented as vertices on the bonding diagram. These factors must be optimized as needed for a particular bonding application to obtain maximum adhesion (or cohesion) between the bonding elements. Bonding factors relate to several functional aspects of the bonding interface or bond line and include the following:

1. Maximizing mechanical interlocking: Increasing the surface roughness increases “lock and key” physical anchoring between the adhesive and surface. A microscopically rough surface increases the area of physical contact and enhances wettability through capillary flow.

2. Matching cohesion energy: The degree of cohesion energy match of the adhesive with the surface should be optimized to create a highly wettable bonding interface. Establishment of such an interface decreases stress in the bondline because continuity exists between the various surfaces - substrate and adhesive.

Figure 1. Bonding factors.
3. **Increasing surface absorption and reactivity:** Surfaces should have sites that are polar or contain reactive chemistries with which the adhesive reacts to form, for example, acid-base pairs. Examples of reactive sites include surfaces containing hydroxyl, carbonyl, carboxylic acid and other functional groups which serve as chemical anchors.

With respect to adhesive bonding, functional aspects are largely responsible for the ability of an adhesive to completely and uniformly wet a technical surface. Wettability is a function of the surface energy of both the adhesive and the substrates. This also includes the physicochemical properties of the adhesive such as the viscosity and surface tension, all of which should be matched to the cohesive energy of the substrate or functionalized surfaces.

An important first step prior to (and sometimes following) preparation of bonding surfaces is precision cleaning to achieve a high degree of surface cleanliness. Surface cleanliness is defined as the absence of foreign materials deposited on bonding surfaces. These include fingerprints, particles, manufacturing process residues, vapors, machining oils, loosely adhering oxides and other surface contaminant layers. Moreover following surface treatment processes such as microabrasive blasting, surfaces are always populated with microscopic abrasive and ablated particle debris. All of these contaminants mask the bonding surface, filling and coating microscopic valleys and asperities with residues that reduce surface area availability which results in reduced bondline adhesion or cohesion strength. Surface contamination also interferes with the functionalization of technical surfaces, masking the surface from the beneficial actions of treatment processes such as for example atmospheric plasma treatment used to increase microscopic surface roughness (i.e., plastics) and activation (i.e., oxygenation).

Surface preparation techniques and goals are different for different types of mating substrates and bonding schemes. Shown in Figure 2, various types of cohesive and adhesive bonding processes are described. The three major categories of bonding or joining processes shown in the figure comprise adhesively joining substrates, the application of coatings to substrates, and the direct bonding (cohesively joining) substrates. A number of factors, some similar and some different, form the basis for reliable joining processes across the various bonding schemes and processes. For example, Figure 3 shows the basis for a reliable adhesive bond. Proper surface preparation forms the foundation for the bondline with important engineering and design considerations such as proper adhesive selection, preparation and application. Other critical factors include joint design and correct adhesive cure schedule. Among these factors, variables affecting the quality and strength of the adhesive and cohesive bonds include surface contamination, surface wetting, cohesive energy, and discontinuities within the cured adhesive. Shown in Figure 4, and similar to adhesive bonding processes, coating and direct bonding processes require the removal of particles, hydrocarbon films and other surface contaminants as well as the creation of wettable or functionalized surfaces.

Substrate surfaces may contain one or a combination of hydrocarbon films and particles and non-wettable or low energy surfaces. Many different surface treatment methods have been developed to address these challenges and these are as diverse as the many surface treatment challenges confronted by manufacturing engineers, but not without limitations. Conventional techniques such as mechanical abrasion that are used to increase surface area. Microabrasive treatments must be exact to prevent physical damage to the surface (overtreatment) and cause secondary particulate surface contamination which must be removed prior to bonding operations. Wipe cleaning techniques using organic solvents such as acetone and methylethylketone (MEK) are undesirable due to odor, toxicity, flammability or volatile organic compound (VOC) issues. Solvent wiping tends to smear contamination over the critical bonding surfaces and does not effectively remove thin film contaminants trapped or hidden within microscopic surface topography. Conventional plasma treatments used to etch or functionalize surfaces cannot efficiently address thick or uneven contaminant films, inorganic residues and particles. Moreover microabrasive and liquid treatment agents used to clean and promote surface adhesion are messy. Finally, most conventional

![Figure 2. Bonding processes.](image)

![Figure 3. Reliable adhesive bonding requirements.](image)
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Figure 4. Surface contamination challenges.

The many surface treatment challenges without introducing secondary contaminations or produce effluents which must be treated. Ideally, such a method should comprise both surface cleaning and surface functionalization to properly prepare a technical surface for bonding.

CO₂ surface treatment technology provides robust bondline surface preparation using numerous singular and hybridized treatment techniques which are completely dry, selective, safe for the environment, and easily adapted to or integrated with new and existing manufacturing processes, tools, lines and automation.

**CO₂ Surface Treatment Technology**

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- Centrifugal CO₂ Immersion-Extraction Treatments
- CO₂ Hybrid Treatments