Feng Instruments

Hybrid Carbon Fiber/Wood String Instruments

Our mission: to bring the magic of
Stradivarius to musicians everywhere

The Story:

In the world of string instruments, the name “Stradivarius” has a legendary, almost mythical connotation. The allure of the old Italian masters is so compelling that most of us as musicians dream to own one, but few of us ever will; we are all looking for that rich, refined, clear, powerful, balanced, and resonant sound that characterizes the sound of these great instruments.

Over 300 years later, we have seen instruments made out of many unique materials: aluminum, balsa, and carbon fiber, just to name a few. Yet none of these have been able to capture the very particular combination of tonal qualities that make great violins so appealing.

By using an innovative fusion of carbon fiber and traditional violin making materials and techniques, Feng Instruments brings to our fellow musicians instruments that share the qualities that make Stradivari’s instruments so magical, while maintaining the tradition of lutherie and the appearance of a traditional instrument.

Contact:

Please visit fenginstruments.com to contact me, or for more information

The Science behind the magic

Below is an excerpt of the scientific basis of the acoustics behind the design of these instruments; the reality is much more in-depth than I can explain in the space below, though the basic principle stands: better materials translates to better sound.

Researchers across the world have been studying violin acoustics in a scientific context for decades, though there is still much debate as to the actual physical mechanisms and how they relate to sound. Unfortunately, most of the work published has been either isolated from the system level interactions (i.e. free plate tuning), and the system level studies have not been in the form of well controlled experiments. Understandably, violins are very difficult to study since the wood is so vital to the sound, yet no two pieces of wood are the same; it is thus very difficult to study the effect of any single change in the context of the system.

Our advantage is that we have been able to study the systemic interactions while varying a single variable, and that has armed us with a surprising amount of profound insight into the murky world of string instrument acoustics. Using this knowledge, we have been able to craft the sound of our instruments to almost any combination of acoustic properties within physical limitations.

The materials used are not the innovation; spruce and maple have been the materials of choice for string instruments for centuries, and recently pure carbon fiber instruments have been developed as well. However, it is the combination of both materials, in a composite sandwich, that allows us to develop a new material that is acoustically superior to either material alone.

Composite sandwich panels are hardly a new invention; they are a very efficient way to increase bending stiffness with very little mass. Recall from your high school physics that resistance to bending increases proportional to h^3; thus a small height increase (thickness in the context of violin plates) leads to a significant increase in stiffness. The reason for this h^3 relationship is that the stresses at the edge of the material are much greater than at the center - imagine a beam in bending. At the center of the beam (the neutral axis), there is very little (ideally zero) movement and therefore no resistance to bending. However, the edges must move in tension or compression significantly more than the center, and thus stiffness at the edges provides more bending stiffness than stiffness at the center of the beam. The same principle is applied with sandwich panels: by having a stiff material only at the edges of the beam and a lighter, less stiff material in the center section of the beam, a target stiffness can be achieved with significantly less weight.

So, we have a path to a stiffer and lighter material. How does that help us in the world of acoustics? Enter the concept of acoustic efficiency. Given an energy input, a material will vibrate. How much that vibration translates into sound depends primarily on 1) how lossy the material is (damping), and 2) the frequency dependent radiation efficiency. The first point is fairly obvious: a material with high damping with convert more input energy into heat and less into sound. This effect has a very important effect though, as damping is frequency dependent and varies between materials, and contributes strongly to the characteristic "wood" sound. The second point is less obvious. For a material to radiate sound, the bending vibrations in the material must be able to couple to the air in order to transmit the vibrations to the air. For an infinite plate, there is a critical frequency (also called coincidence frequency) below which a material cannot radiate sound, where the wavelength of the bending wave in the material is less than the acoustic wavelength of air. Coincidence frequency depends solely on material parameters for a given geometry, namely speed of sound in the material. Since speed of sound is directly proportional to the square root of stiffness divided by density, we can see that the ratio of bending stiffness to density will determine the critical frequency of the plate.

In the context of the overall instrument, the role of the top is to radiate sound towards the audience, so we want it to be stiff and light. In addition, a lighter top will respond more easily, both to bow inputs and other acoustic modes, since there is less mass to accelerate. The total frequency response of the top determines the instrument's character, resonance, and its radiated sound.

A good top alone is not enough to create a great instrument - a great back is vital. The back serves a few purposes: 1) it stiffens the top through the soundpost, 2) it "reflects" sound back through the top instead of radiating sound, thus allowing the top to radiate the majority of the acoustic energy, 3) creates air modes through volume expansion and contraction, and finally 4) adds its own excitation modes to the top radiation.

Together, the two plates make up the majority of the acoustic interactions that shape the sound of the instrument. Both plates must have great properties for the overall instrument to have a great sound. Using carbon fiber allows us to improve the acoustic properties of both plates, and bring you the instrument you see today.

The Instruments:

Just as each piece of wood is unique, so is each instrument. Each instrument has its own voice, but must possess richness, resonance, refinement, and power to the highest standard.

- Richness: The difference between a good instrument and a great instrument is often the richness of the sound that imparts a "character" on each great instrument. The huge broad sound that great instruments project is a combination of strong fundamental tones and a vast array of overtones that give these instruments their greatness.
- Resonance: Wood has an order of magnitude more damping that carbon fiber. In fact, this reason is one of the primary reasons carbon fiber instruments exist today; the "ring" of the material is a major factor in resonance and one of the major strengths of pure carbon fiber instruments. However, too much resonance can be a problem as well, as the resonance interferes with the fundamental tone. Our instruments are, unsurprisingly, more resonant than a wooden instrument but less so than a carbon fiber instrument.
- Refinement: Clarity and refinement is one advantage of carbon fiber; as a relatively homogeneous material, there are few imperfections that can create a muddy or harsh sound. Clarity is an advantage the reduced damping of carbon fiber. Our instruments are clear yet rich, and powerful but not harsh.
- Power: Our instruments are engineered to project their rich sound to the end of any concert hall. Volume comes from wood that has a high stiffness to weight ratio, and thus high radiation ratio; projection comes from a top that efficiently radiates sound towards the audience.

Each instrument that we create starts as a hand-picked donor instrument. The donor instruments are selected very carefully based on three criteria: worksmanship, appearance, and most importantly, wood selection. The wood used on the instruments that are selected have good acoustic properties: high stiffness to weight ratio, low damping, which is carefully graduated down to a chosen balance of stiffness and weight.

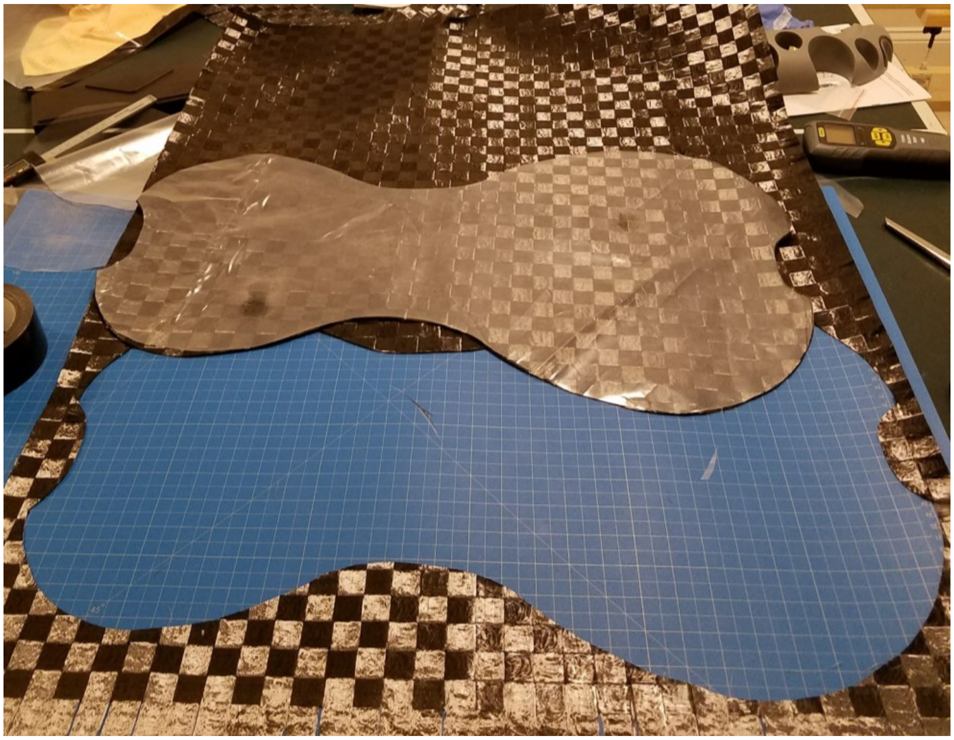
Caring for Your Instrument:

As our instruments are still primarily made from traditional wood, the criteria for instrument care are exactly the same as traditional wood instruments. String instruments prefer a stable environment (avoid sudden changes in temperature or humidity), and prefer room temperature, and 30-50% relative humidity. Like a traditional instrument, as the relative humidity changes with the seasons, the string heights may change as well. In addition, soundpost fitment should be checked seasonally since the instrument contracts and expands with humidity.

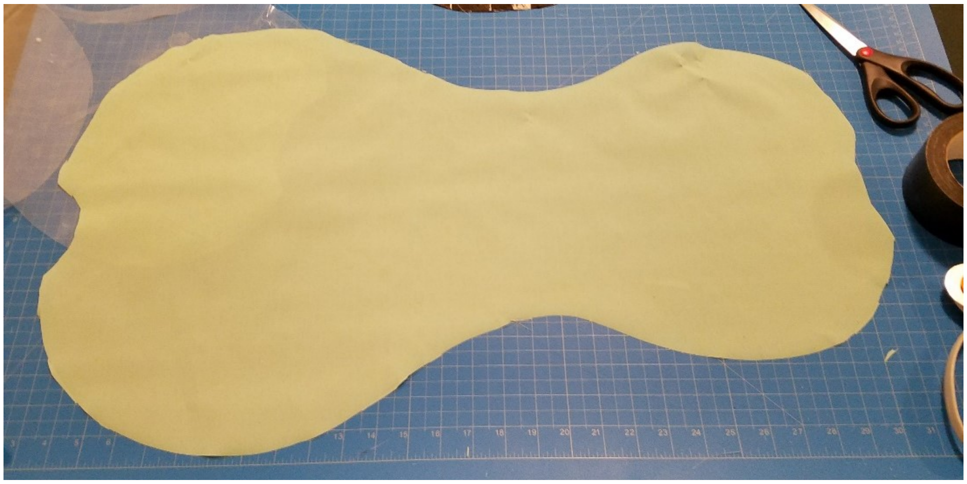
The Build Process

The build process starts with removing the top:

Both plates are then graduated to specific thicknesses, stiffnesses, and modal frequencies. Next, the carbon fiber process begins. For the back, first, the carbon fiber is measured and cut using a template created from the instrument itself:



Next, a layer of peel ply is cut slightly larger than the carbon fiber. The porous peel ply allows the excess epoxy to seep into a breather material as vacuum is pulled, and allows for the breather (and thus excess epoxy) to be removed after the epoxy has cured.



Next, the carbon fiber is applied to the instrument, and epoxy is applied to the carbon fiber:

Once the epoxy is applied, the peel ply and breather are laid on top of the carbon fiber/epoxy mixture:

Finally, the entire assembly is inserted into a vacuum bag, and vacuum is pulled. The vacuum squeezes any excess epoxy out of the carbon fiber, thus leaving a minimum amount of heavy (and weak) epoxy in the matrix. This maximizes the stiffness to weight ratio of the carbon composite material.

The top follows a very similar process, though with a different type of carbon fiber, and a much smaller vacuum bag (as it only has to hold the plate). The varnish is protected by a micro-fiber cloth so as not to imprint any creases from the vacuum bag onto the varnish.

Once the carbon fiber has been cured, the instrument is glued back together using traditional lutherie techniques.