

SHORT CURRICULUM VITAE

Nicola M. Pugno, Prof. Dr.

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A. EDUCATION

1995: Master Degree in Mechanical Engineering, Politecnico di Torino, 110/110 cum laude (20 July 1995).
1999: PhD in Structural Engineering, Politecnico di Torino (15 March 1999).
2004: Master Degree in Physics, Facoltà di Scienze Matematiche, Fisiche e Naturali, Università di Torino, 110/110 cum laude (29 April 2004).
2015: PhD in Biology, Facoltà di Scienze Matematiche, Fisiche e Naturali, Università di Torino (25 February 2015).

B. CURRENT AND PREVIOUS ACADEMIC POSITIONS

2000: Assistant Professor of Solids and Structural Mechanics at Politecnico di Torino, from 1 October 2000.
2005: Associate Professor of Solids and Structural Mechanics at Politecnico di Torino, from 1 October 2005.
2009: Founder and Director of the Laboratory of Bio-inspired Nanomechanics „Giuseppe Maria Pugno” at Politecnico di Torino
(https://www.diseg.polito.it/il_dipartimento/strutture_interne/centri_e_laboratori/laboratorio_bio_inspired_nanomechanics).
2012-: Full Professor of Solids and Structural Mechanics at the University of Trento, from 1 November 2012.
2012-: Founder and Director of the “Laboratory for Bioinspired, Bionic, Nano, Meta Materials and Mechanics” at the University of Trento (<https://pugno.dicam.unitn.it/>).
2013-: Full Professor of Material Science (20% FTE) at the Queen Mary University of London, from 1 October.
2013-: Scientific Responsible for the Design of Graphene Nanocomposites, within the Graphene Flagship, at the Fondazione Bruno Kessler first and then at the Fondazione Edoardi Amaldi and currently at the Queen Mary University of London.
2019-: Visiting professor at Oxford University.

C. RECENT PROFESSIONAL ACTIVITIES

First editor in chief of Frontiers in Materials (IF 3.515, and of its section Mechanics of Materials).
Member of the editorial board of dozens of journals, including Scientific Report of Nature Publishing Group and Matter of Cell Press.
Member of several committees including the Scientific and Technical Committee of the Italian Space Agency (ASI).

D. INVITED LECTURES

Plenary and keynote speaker at several conferences and events, including Falling Walls invited by the European Research Council (ERC), European Parliament invited by ERC, 5000th grantee celebration at ERC, World Economic Forum, invited as young scientist by ERC. The last one was the Opening plenary lecture at the quadrennial 25th International Congress of Theoretical and Applied Mechanics (ICTAM 2020+1) selected by the Congress Committee of the International Union of Theoretical and Applied Mechanics (IUTAM), video and extended abstract available at:
https://pugno.dicam.unitn.it/news/2021_plenary ICTAM.mp4
https://pugno.dicam.unitn.it/news/2021 ICTAM_ExtendedAbstract.pdf

E. RESEARCH INTERESTS AND RELATED PUBLICATIONS

Nanomechanics, fracture mechanics, solid and structural mechanics, tribology, wettability, adhesion, nanomaterials, bio-inspired materials, natural materials, biomaterials, metamaterials, nems and mems. 530 international journal papers, see <http://www.ing.unitn.it/~pugno/index.html>

F. MEMBERSHIPS

Several, including Associazione Italiana di Meccanica Teorica e Applicata (AIMETA) and European Mechanics Society (EUROMECH).

G. 10 EXAMPLES OF INTERNATIONAL JOURNAL PUBLICATIONS

1. A. Carpinteri, N. Pugno. [Are the scaling laws on strength of solids related to mechanics or to geometry?](#), NATURE MATERIALS (2005), 4, 421-423.
2. S.W. Cranford, A. Tarakanova, N. Pugno, M.J. Buehler. [Nonlinear material behaviour of spider silk yields robust webs](#), NATURE (2012), 482, 72-78. Cover Story and 18 pages of Supplementary Information, DOI 10.1038/nature10739.
3. R. Meija, S. Signetti, A. Schuchardt, K. Meurisch, D. Smazna, M. Mecklenburg, K. Schulte, D. Erts, O. Lupan, B. Fiedler, Y.K. Mishra, R. Adelung, N. Pugno. [Nanomechanics of individual aerographite tetrapods](#). NATURE COMMUNICATIONS (2017), 8, 14982.
4. I. Polishchuk, A.A. Bracha, L. Bloch, D. Levy, S. Kozachkevich, Y. Etinger-Geller, Y. Kauffmann, M. Burghammer, C. Giacobbe, J. Villanova, G. Hendler, C.-Y. Sun, A.J. Giuffre, M.A. Marcus, L. Kundanati, P. Zaslansky, N. Pugno, P.U.P.A. Gilbert, A. Katsman, B. Pokroy. [Coherently aligned nanoparticles with a biogenic single crystal: A biological prestressing strategy](#). SCIENCE (2017), 358, 1294-1298.
5. N Pugno, R. Ruoff, [Quantized Fracture Mechanics](#). PHILOSOPHICAL MAGAZINE, PP. 2829-2845, 2004, VOL. 84, ISSN: 1478-6435
6. N. Pugno, [Mimicking nacles width super-nanotubes for producing optimized super-composites](#). NANOTECHNOLOGY, PP. 5480-5484, 2006, VOL. 17.
7. N. Pugno, [The role of defects in the design of the space elevator cable: from a nano to a mega tube](#). ACTA MATERIALIA, PP. 5269-5279, 2007, VOL. 55, ISSN: 1359-6454.
8. N. Pugno, [A general shape/size-effect law for nanoindentation](#). ACTA MATERIALIA, PP. 1947-1953, 2007, VOL. 55.
9. N. Pugno, [The design of self-collapsed super-strong nanotube bundles](#). J. OF THE MECHANICS AND PHYSICS OF SOLIDS (2010), 58, 1397-1410.
10. D. Liprandi, F. Bosia, N. Pugno. [A theoretical-numerical model for the peeling of elastic membranes](#). JOURNAL OF THE MECHANICS AND PHYSICS OF SOLIDS (2020), 136, 103733.

H. GRANTS & PRIZES

- ERC Starting (II, then called Consolidator) Grant „Bihsnam“ on “Bio-inspired Hierarchical Super Nanomaterials”, 2012-2016 (<https://cordis.europa.eu/project/id/279985/it>).
- ERC Proof of Concept „Replica²“ on “Large area replication of biological anti-adhesive nanosurfaces”, 2013a (<https://cordis.europa.eu/project/id/619448/it>).
- ERC Proof of Concept „Knotough“ on “Super-tough knotted fibers”, 2013b (<https://cordis.europa.eu/project/id/632277/it>).
- ERC Proof of Concept, on “Silkene” on Bionic silk with graphene or other nanomaterials spun by silkworms, 2015 (<https://cordis.europa.eu/project/id/693670/it>).
- Graphene Flagship (WP Composites, 2012-, local responsible, <https://cordis.europa.eu/project/id/881603/it>).
- Fet Proactive „Neurofibres“ on Biofunctionalised Electroconducting Microfibres for the Treatment of Spinal Cord Injury, 2018-2021 (local responsible, <https://cordis.europa.eu/project/id/732344/it>).
- Fet Open „Boheme“ on „Bioinspired hierarchical metamaterials,,“, 2020-, coordinator (<https://cordis.europa.eu/project/id/863179/it>).
- Life EU „Green Vulcan“ on High performance devulcanized masterbatches for end-to-life tire reuse in high-volume technical compounding 2020- (<https://www.lifegreenvulcan.eu/>)
- Several national (e.g. pon, prin as coordinator) and regional (e.g. caritro) grants.
- Winner of prizes for science popularization and science advancement, namely First edition of Giovedì Scienza prize in 2012 and the Griffith medal and prize in 2017.

I. INDUSTRIAL RESEARCH

Consultant for several high-tech companies, including for their long term vision, e.g. for Toyota Motor Europe.

Trento, 15 October, 2021



SUPPLEMENTARY INFORMATION

• SUPERVISION OF GRADUATE STUDENTS AND POSTDOCTORAL FELLOWS

- 2012 – present about 5 Post-docs, 25 PhD students, 10 Master Students at the UNITN, Italy
- 2014 – 2016 1 Postdoc, Fondazione Bruno Kessler, Trento, Italy
- 2005 – 2012 1 Postdoc, 5 PhDs, 30 Master Students at POLITO/Alta Scuola Politecnica, Italy. Among supervised PhD students, several are in good academic or company positions (e.g. Dr. Qiang Chen is currently Associate Professor at Southeast University, Nanjing, China)

• TEACHING ACTIVITIES

- 2001– present Lecturer of “**Structural and Solid Mechanics**” at POLITO and UNITN
- 2010– 2011 Lecturer of the advanced course “**Bio-Inspired Advanced Nanomechanics**”, also given and organized by the PI at the International Centre for Mechanical Sciences (Udine, 2011, including Nobel laureate H. Kroto)
- 2004– 2011 Lecturer of “**Bio & Nano Structural and Solid Mechanics**” at POLITO and UNITN
- 1996 – 2001 Assistant to the Course of “**Structural and Solid Mechanics**” at POLITO
- 2007- present Extensive media science divulgation, especially of ERC results, including in ERC Newsletters, European Commission Newspaper, ERC animations, etc.

• ORGANISATION OF SCIENTIFIC MEETINGS (selected examples)

- 2016 "Computational bio and bio-inspired mechanics from nano to micro" at the 12th **World Congress on Computational Mechanics**, Seoul (Korea).
- 2015 Minisymposium “Nanomechanics and Micromechanics” at the 9th **European Solid Mechanics Conference**, Madrid, Spain.
- 2014 Symposium “Soft Nanomaterials” at the **MRS Spring 2014 Meeting**, San Francisco, California.
- 2013 International Scientific Committee and Co-Chair of Session “Biomaterials and Tissues” and Minisymposium “Materials and Structures under severe conditions” of the **Int. Conf. on Fracture 13**, Beijing, China.
- 2012 Symposium “De Novo Graphene and Carbon Nanomaterials” at **MRS Spring 2012 Meeting**, San Francisco, California.

• INSTITUTIONAL RESPONSIBILITIES (selected examples)

- 2013–2018 Vice-director of the Doctoral School in Civil, Environmental and Mechanical Engineering at the University of Trento
- 2014 Member of the Strategic Vision Committee of the Fond of Fund Venture Capital (FOF VC), of the Fondo Italiano d’Investimento SGR S.p.A.
- 2014, 2015 Member of the jury (headed by Professor Carl-Henrik Heldin, Chairman of the Board of the Nobel Foundation) at the Falling Walls Final Event in Berlin.
- 2014, 2015 Member of the 2013 Volkswagen Stiftung Jury for the “Experiment!” competition

• REVIEWING ACTIVITIES (selected examples)

- First Editor-in-Chief of **Frontiers in Materials** (from 2017) and Specialty Editor (from 2014) of its session - **Mechanics of Materials**.
- Academic Editor of **PLoS ONE**, Public Library of Science, from 2014.
- Editorial Board Member of **Scientific Reports**, Nature Publishing Group, from 2014.
- Editorial Board member of **several** International Journals, e.g. **Journal of Adhesion** (Taylor and

Francis), **BioNanoScience** (Springer) and **Materials** (MDPI).

- Referee for many Int. Journals, e.g. **Nature**, **Nature Materials**, **Nature Communications**, **Journal of the Mechanics of Physics of Solids**, **Advanced Materials**, etc. and referee for different Institutions, e.g. **ERC** (as external expert for AdG), **National Science Foundation** and Italian Ministry of Science and Education (**MIUR**).

- **MEMBERSHIPS OF SCIENTIFIC SOCIETIES (selected examples)**

2012 – present Member of the Young Academy of Europe

2005 – present Member of the Associazione Italiana di Meccanica Teorica e Applicata

2014 Member of the Istituto Nazionale di Alta Matematica

- **MAJOR COLLABORATIONS (selected examples)**

Prof. **A. Ferrari**, Cambridge University (Cambridge, UK), on graphene; Prof. **M. Buehler**, MIT (Boston, Massachusetts, USA) nanomechanics of biological materials; Prof. **S. N. Gorb**, Kiel University (Germany) on bio-inspired adhesion; Prof. **H. Gao**, Brown University (Providence, Rhode Island, USA), on nanomechanics; Prof. **D. Galvao**, State University of Campinas (San Paolo, Brasil), on graphene nanoscrolls; Prof. **S. Ketten** and Prof. **H.D. Espinosa**, Northwestern University (Evanston, Illinois, USA), on MEMS; Prof. **R.S. Ruoff**, Northwestern University (Evanston, Illinois, USA), on graphene.

- **10-YEAR TRACK RECORD**

Despite his relatively middle age, Nicola M. Pugno (NMP) is one of the leading names in Europe in Bioinspired, Nano, Fracture, Solids and Structural Mechanics. One of his skills is interdisciplinary research, which lies at the heart of this proposal. This skill has been acquired along the years focusing not only on research but also on the study of different disciplines. In particular, NMP holds **two degrees, in Mechanical Engineering and in Physics** as well as **two Ph.Ds, in Structural Engineering** (specifically in Fracture Mechanics) **and in Biology and Applied Biotechnology** (specifically on spider silk). His main achievements are documented in nearly 530 international journal papers, published in major journals including *Science*, *Nature*, *Nature Materials*, *Nature Communications*, *Advanced Materials*, *Advanced Functional Materials*, *Small*, *Physical Review Letters*, *Materials Today*, *J. of the Mechanics and Physics of Solids*, etc. Some of his single-authored papers have been highlighted by international scientific press (*Nature*, *New Scientists*, *MIT Technology Review*, etc.), and have been selected as top papers of the year by the Institute of Physics (IoP). Today, his ***h-index* value is 65, *i10-index* is 308**, and his number of **citations is 19860**; from 2016 these numbers are respectively 51, 242, 13730 (google scholar). This indicates that his work is generally highly regarded and one of the most cited in Italy in his field (see topitalianscientists.org), even when compared to top senior researchers, and still presents a positive gradient. Apart from his numerous publications, the NMP's recognition is testified by his wide scientific and institutional responsibilities, including the selection by the President of the Italian Space Agency (ASI) in its Scientific and Technical Committee as representative for Materials and Structures. Public engagement activities include collaborations with national daily newspapers in Italy on scientific issues and his appearances on various radio and TV broadcasts, including national TV news programs, to speak about his work previously funded by ERC. His group also pursues several significant collaborations with industry, e.g. regularly with Toyota Motor Europe NV/SA (Bruxelles, Belgium) also on their 2050 material vision, demonstrating that even basic research can become fundamental in the strategic vision of leading companies.

Main past research topics

- Bionic materials, such as graphene reinforced silk directly spun by spiders;
- Bio-inspired hierarchical super nanomaterials, including self-healing;
- Metamaterials, including seismic shields and hierarchical;
- Smart adhesion of insects, spiders and geckos and related gecko-inspired nanostructured surfaces;
- Self-cleaning & anti-adhesive super-hydrophobic leaves and related lotus-inspired nanostructured surfaces;
- Spider-silk and web and related spider-inspired super-tough materials and structures;
- Hierarchical fibre bundle models, ropes, tissues and cellular solids;
- Super-strong graphene, carbon nanotubes and related bundles and composites;
- Mechanical models for applications in medicine, such as tumor growth, spinal cord injury, nanovectors;
- Quantized Fracture Mechanics, in quasi-static, dynamic and fatigue regimes;
- Nanoscale Weibull & Fractal Statistics and related size-effects on material strength;
- Design and fabrication of Nano Electro Mechanical Systems;
- Nanotribology of complex patterned surfaces, simulations and experiments.

10 Representative Publications

Complete list at <http://www.ing.unitn.it/~pugno/pugnopub.html>. Hundreds of papers published in international journals, international volumes, international or national conference proceedings on Structural-, Solid-, Fracture-, Bioinspired and Nano- Mechanics. Nearly **530 papers** published in international journals in solid and structural mechanics. The chosen 10 representative papers in the 2011-2021 period are:

1. **N. Pugno**. The “Egg of Columbus” for making the world's toughest fibres. *PLoS ONE* 9 (4), e93079, 2014 (→ *use of knots as energy dissipators to achieve extreme toughness, as milestone of PI's ERC StG*)
2. F. Bosia, T. Abdalrahman, **N. Pugno**. Self-Healing of Hierarchical Materials. *Langmuir* (2014), 30, 1123-1133 (→ *mesoscopic model for self-healing in hierarchical structures*)
3. A.H. Barber, D. Lu, **N. Pugno**. Extreme strength observed in limpet teeth. *Journal of the Royal Society Interface* 12, 20141326, 2015 (→ *discovery of the strongest natural material*)
4. M. Fraldi, G. Perrella, M. Ciervo, F. Bosia, **N.M. Pugno**. A hybrid deterministic-probabilistic approach to model the mechanical response of helically arranged hierarchical strands. *Journal of the Mechanics and Physics of Solids* 106, 338-352, 2017. (→ *design of hierarchical cables*)
5. I. Polishchuk, A.A. Bracha, L. Bloch, D. Levy, S. Kozachkevich, Y. Etinger-Geller, Y. Kauffmann, M. Burghammer, C. Giacobbe, J. Villanova, G. Hendler, C.-Y. Sun, A.J. Giuffre, M.A. Marcus, L. Kundanati, P. Zaslansky, **N. Pugno**, P.U.P.A. Gilbert, A. Katsman, B. Pokroy. Coherently aligned nanoparticles with a biogenic single crystal: A biological prestressing strategy. *Science*, 358, 1294-1298, 2017. (→ *first observation of a precompression toughening strategy in Nature*)
6. R. Meija, S. Signetti, A. Schuchardt, K. Meurisch, D. Smazna, M. Mecklenburg, K. Schulte, D. Erts, O. Lupan, B. Fiedler, Y. K. Mishra, R. Adelung and **N.M. Pugno**, Nanomechanics of individual aerographite tetrapods, *Nature Communications*, 8: 14982, 2017. (→ *nanomechanical characterization of single tetrapod for the design of aerographite*)
7. E. Lepore, F. Bonaccorso, M. Bruna, F. Bosia, S. Taioli, G. Garberoglio, A. Ferrari and **N. Pugno**, “Spider silk reinforced by graphene or carbon nanotubes,” *2D Materials*, 4, 031013, 2017 (→ *first proof-of-concept of bionic spider silk*)
8. S. Elsharkawy, M. Al-Jawad, M.F. Pantano, E. Tejada-Montes, K. Mehta, H. Jama, S. Agarwal, K. Shuturminska, A. Rice, N.V. Tarakina, R.M. Wilson, A.J. Bushby, M. Alonso, J.C. Rodriguez-Cabello, E. Barbieri, A. del Río Hernández, M.M. Stevens, **N. Pugno**, P. Anderson, A. Mata. Protein disorder-order interplay to guide the growth of hierarchical mineralized structures. *Nature Communications*, 9, 2145, 2018. (→ *potential complex material design strategy for hard tissue repair*)
9. L. Kundanati, S. Signetti, H.S. Gupta, M. Menegon, **N. Pugno**. Multilayer stag beetle elytra perform better under external loading via non-symmetric bending properties. *Journal of the Royal Society Interface*, 15, 20180427, 2018. (→ *novel bioinspired microstructures for composite design in different loading configurations*)
10. L. Xi, P. De Falco, E. Barbieri, A. Karunaratne, L. Bentley, C.T. Esapa, N.J. Terrill, S.D.M. Brown, R.D. Cox, G.R. Davis, **N. Pugno**, R.V. Thakker, H.S. Gupta. Bone matrix development in steroid-induced osteoporosis is associated with a consistently reduced fibrillar stiffness linked to altered bone mineral quality. *Acta Biomaterialia*, 76, 295-307, 2018. (→ *two-level hierarchical model of the bone matrix to predict fibrillar mechanical response*)

Invited talks

He has held about **50 invited talks**, among which about **15 plenary lectures** in international conferences and over **30 invited lectures or seminars** at international research institutes. The following is a selection of 13 recent invited lectures:

1. Plenary Opening Lecture at the 25th International Congress of Theoretical and Applied Mechanics (ICTAM 2020), 23-28 August 2020, Milan, Italy.
2. Horizon 2050: Super-materials for zero footprint, invited talk (by ERC) at the European Business Summit, 22-23 May 2017, Bruxelles, Belgium, given with Dr. K. Gkagkas, Toyota Motor Europe.
3. Plenary lecture at *Materials 2015 - VII International Materials Symposium*, 21-23 June 2015, Porto, Portugal.
- 4-5. Two Invited lectures by ERC: for the ERC celebrations for 5000 funded grants, 16 June 2015, Solvay Library, Bruxelles and as representative of the 5000 ERC grant winners at the European Parliament (with ERC President), 16 June 2015, European Parliament, Bruxelles.

6. Invited Lecture: L'avvento della Nanomeccanica, *Accademia Nazionale dei Lincei*, 10 January 2014, Roma, Italy.
7. Live national TV: *The sustainable link in a new approach between Europe and the Arab Nations, Round Table* (including Nobel Laureate Mario J. Molina), 26 October 2013, Rimini, Italy.
8. Invited by Young Academy of Europe: Graphene and bio-inspiration. *25th Anniversary Conference of the Accademia Europaea* (for AE members elected in 2012 and Young AE members), Wroclaw, Poland, 16-19 September 2013.
9. Plenary Lecture, invited by ERC: *Falling Walls Conference: Future Breakthroughs in Science and Society*, 9 November 2012, Berlin, Germany.
10. Plenary Lecture (plenary lecturers included Nobel Laureate A. Fert): Nanomechanics of graphene. *GRAPHEL*, 27-30 September 2012, Mykonos, Greece.
- 11-12. Two Invited lectures by ERC: Designing nature-inspired super materials, in IdeasLab Harnessing Science with Nature Magazine (Facilitated by Dr. Campbell, Editor-in-Chief, Nature Magazine), and From mind to market: energy materials (Facilitated by Dr. DiChristina, Editor-in-Chief, Scientific American), *World Economic Forum*, 11-13 September 2012, Tianjin, China.
13. Plenary Lecture: Fracture and adhesion of super-nanomaterials, *19th European Conference on Fracture*, 26-31 August 2012, Kazan, Russia.